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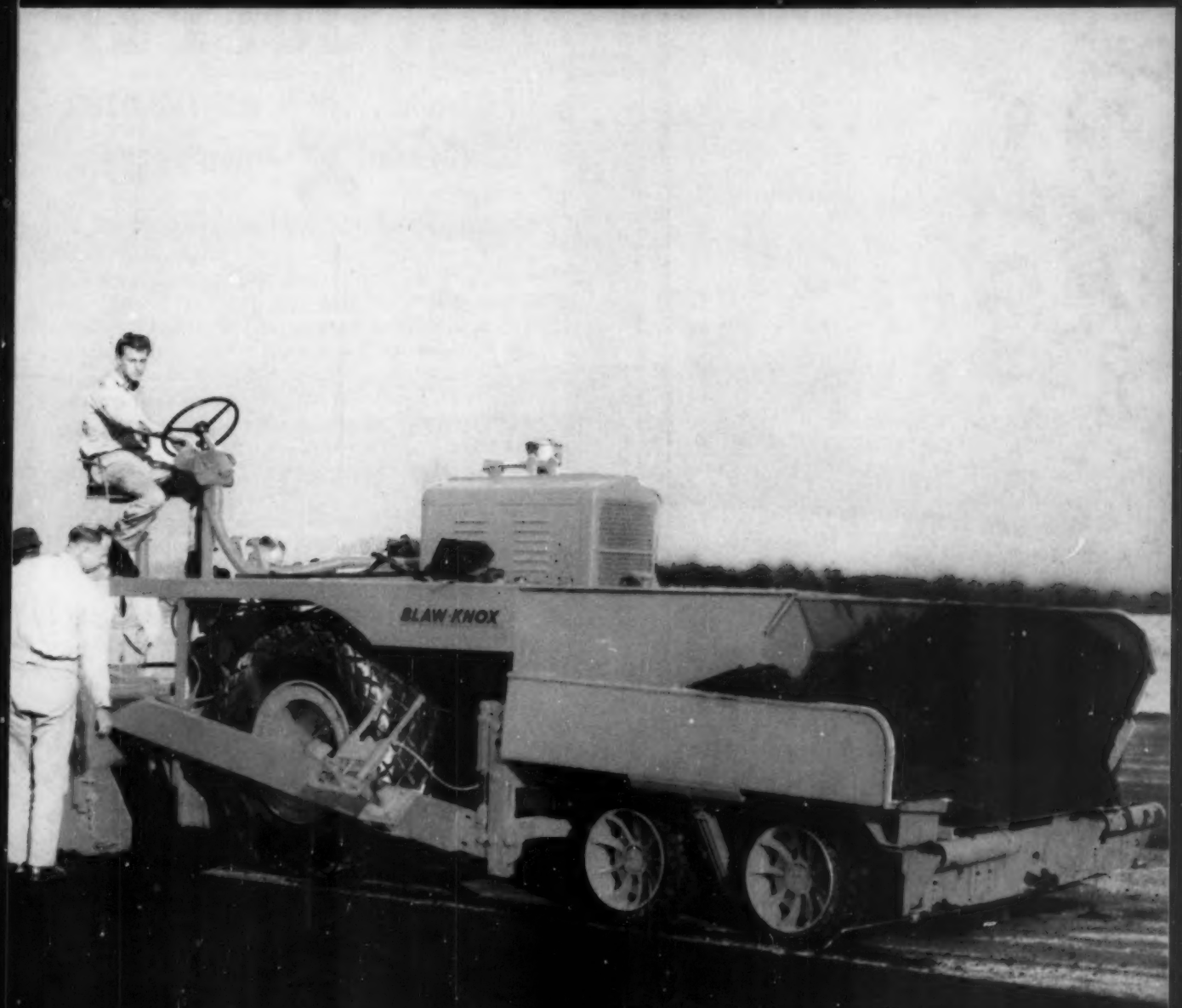
PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · JANUARY 23, 1961



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- LINKAGES FOR POWER CYLINDERS . . . page 48
- THE HIGH-STRENGTH STEELS—WHAT THEY OFFER . . . page 54

BEST BUY FOR AIR SUPPLY

UP TO 5hp... NEW WORTHINGTON MONOBLOC X-COMPRESSOR

Based on purchase price, on extremely long compressor life . . . and on safety, too . . . your best buy for a 1½- to 5-h.p. air supply is the new Worthington MONOBLOC X-Compressor.

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

January 23, 1961 Vol. 32, No. 4

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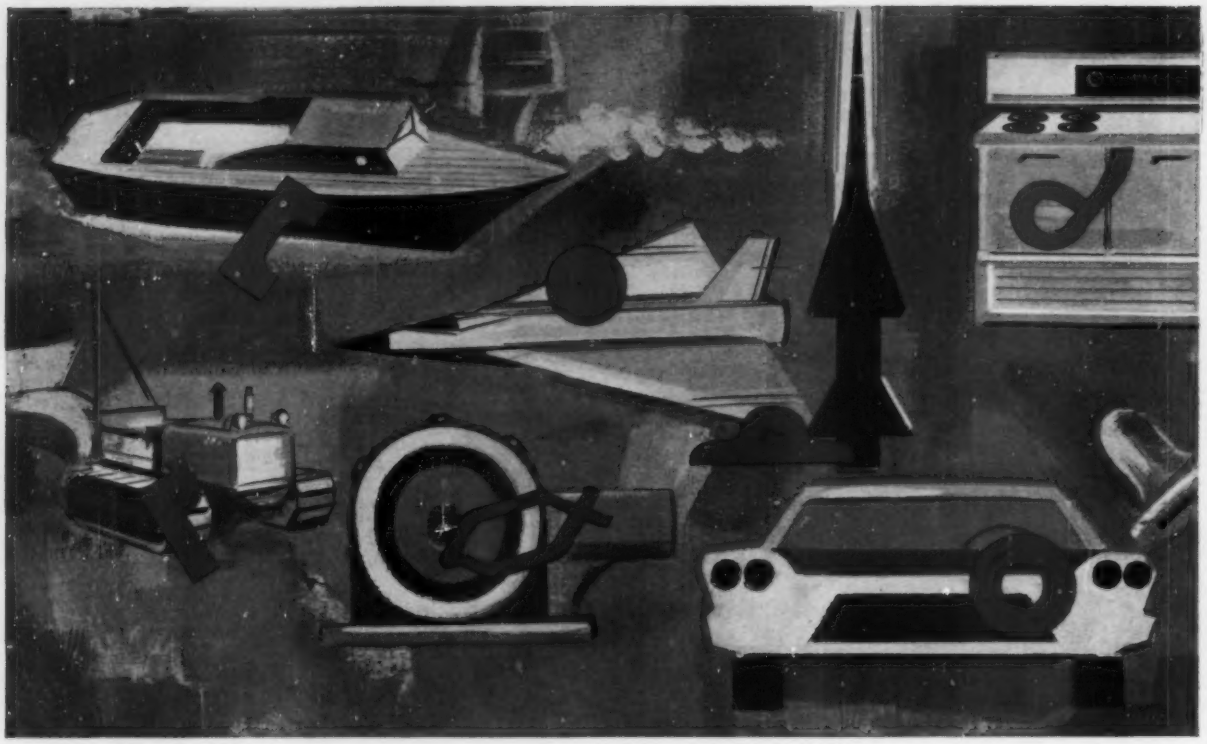
SILICONE NEWS from Dow Corning

Design For Quality



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INTERESTING TO NOTE

On our cover—new Blaw-Knox bituminous paver performing for Don Davin, the project engineer for the machine. As the article on page 44 points out, electrical, hydraulic and pneumatic control systems make all functions automatic, including forward speed and steering of the machine, and surface height and density of the pavement. The skill is designed into the machine.

Road building began with the Romans as an engineering art, which declined and was not pursued again until the 18th century when the Industrial Revolution in England stimulated commerce between towns. The condition of English roads was so poor, according to Daniel Defoe, that "the inland trade of England has been greatly obstructed by the exceeding badness of the roads." Merchants had to transport their goods during the dry months—most of the thoroughfares turned into rivers of mire after a heavy rain.

It was at this time that British engineers began building roads very much like those of the Romans, using crushed rock as the principle road material. But the binder varied greatly. By coincidence the English knew of asphalt, for Sir Walter Raleigh observed ship builders in Trinidad using it as a caulking material, but no one thought of it as a paving material.

It was the Scotsman, John L. McAdam, who in the late 1800's designed the first successful roads using hot bituminous cement as a binder. In his book, "Remarks on the Present System of Road Making," McAdam detailed the secret of road building—"that the road foundation must be thoroughly drained, and thickness of the road should only be regulated by the quantity of material necessary to form such impervious covering, and never by any reference to its own power of carrying weight." While McAdam's road-

Bettmann Archive

English highway circa 1805. Note the broad-rimmed wheels. They were used to smooth out ruts in muddy highways. The English government exempted operators of truck fleets from highway taxes if they agreed to use wagon wheels 10 or more inches wide.

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building contemporaries were constructing fancy, expensive roads, the Scotsman's insistance on a dry subsoil and the use of small rocks in construction, meant that road surfaces rarely needed to be thicker than a few inches.

While England built "macadam" roads, young America struggled with its own problems. In 1771, a 90-mile trip by stagecoach between New York and Philadelphia took a day and a half including a midnight ferry ride across the Hudson and many sore hours aboard a springless coach, advertised as the "Flying Machine." Today, buses do it in 2 hr over a bituminous surface.

Steel's "Big Three" Inventors

It's an interesting coincidence that so often a major invention is announced about the same time a second inventor, unknown to the first, has developed a similar device and is all but ready to also announce his own development. When Michael Faraday published his paper on electromagnetic induction, Joseph Henry was left holding his data. Faraday received the credit but Henry may well have been first to conceive the idea. Also, Edison is credited with inventing the gramophone though there is evidence that Alexander Bell had a model working successfully before Edison. The development of the pneumatic process of making steel is another example of two men developing a similar process at the same time. One was the American, William Kelly; the other, Englishman Henry Bessemer.

In 1847, Kelly blew cold air through molten pig iron at the Eddyville furnace in Kentucky. It took him a full decade before he got around to applying for a patent—but then it was too late. Bessemer had applied for a patent in 1855—two years before Kelly. Bessemer's converter was of great industrial importance although means of producing steel had been known for centuries. Bessemer made his discovery while trying to better the steel used in the manufacture of cannon. When he blew air through molten metal he was surprised to find that it not only purified the iron, but also that heat generated by the oxygen kept the iron fluid.

There is yet a third man who made a valuable contribution to the steelmaker's art, Robert F. Mushet.

Like Bessemer, Mushet was English. He grew up in Forest of Dean, an area rich in iron ore. His father operated an iron and steel plant and upon his death, young Robert took over. In 1848, a friend of Mushet's, who had been traveling in Prussia, brought him a specimen of a white crystalline metal. The friend thought it might be pure iron, but Mushet recognized it as an alloy of iron, manganese and carbon. Because of its high sheen it was called spiegeleisen, meaning "mirror-iron." Mushet ordered 12 tons of the alloy and combined it with the iron and steel in his furnaces. He found that the spiegeleisen not only reduced cost of production, but also gave a better quality steel.

Mushet's process went unnoticed until after Bessemer invented his converter. Then he was able to use the Bessemer process with his spiegeleisen alloy to produce high-quality steel in quantity. In 1856, Mushet obtained three patents for his process. These would have made him a rich man had it not been for an unfortunate oversight. Mushet's patent trustees failed to pay the stamp duty on the patents and his rights were forfeited. Fortunately, Bessemer recognized the importance of Mushet's addition to his own invention and granted him an annuity of 300 pounds.

Today, there are thousands of formulas for steels. One particular type, high-strength steel, is the subject of the Special Report on page 54. Benedict A Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Semiconductors Reverse Variable-speed DC Motors**
They work off ordinary line ac; they do without switch-over relays.

. . . **7 Reliability Tests for Synthetic-rubber Coated Fabrics**
The most common tests are illustrated in this photo story.

. . . **Power Cylinder Mechanisms—Intermediate Positions**
Where intermediate positions are required, graphical methods solve the coordination of linear motion of cylinder piston with angular motion of the mechanism.

. . . **Area Heat Sources—Answer to Hot-spot Temperatures**
These heating elements use flat conductors with maximum surface area and intimate contact for lower temperature differential.

. . . **When Designing Journal Bearings**
Gives practical recommendations, based on speed, load and temperature requirements, that go to heart of the problems.

DEVELOPMENTS TO WATCH...

Combination dry lubes show promise at high temperatures

One element is a dry lubricant (lead sulfide) that has good high-temperature (1000 F) properties, but decreasing wear life with decreasing temperature. The other lubricant is one that shows good low-temperature properties, but is not as good at high molybdenum disulfide. The combination, says Midwest Research Institute, is a film-forming compound that looks extremely promising. The materials are bonded by boric oxide; and, says S. L. Levy, director of MRI's Mathematics and Physics Div, "the combination operates over the whole temperature range better than any film tested so far."

As would be expected, of course, top operating temperature is governed by the performance of the "weaker" material—molydisulfide. But wear life is very good, and the compound performs even better in vacuum than in air. Further tests are now in progress, using the Institute's Mark V friction-testing machine, designed to operate at loads to 80,000 psi, speeds to 200 ft/min., and temperatures to 1000 F.

USDA tries new route to truck refrigeration

Cooling by liquid nitrogen spray in place of standard refrigeration is under test by USDA. The advantage: "By replacing warm air in the truck with cold, dry nitrogen, instead of gradually cooling the air, system virtually eliminates time required by conventional methods to pull air temperature down low enough for frozen foods."

A report on the test method (AMS-426) is available from USDA, Washington DC.

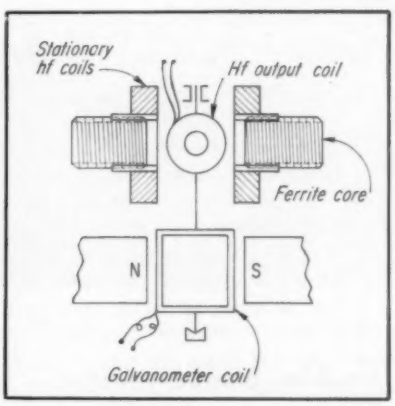
New tube for temporary measurement

A vidicon tube that is sensitive to infrared as well as visible light is being introduced by EMI Electronics Ltd of Middlesex, England.

EMI says the tube can be installed in a standard TV camera and used for burglar alarms and other warning systems as well as for laboratory studies. In conjunction with an oscilloscope, it permits high-accuracy temperature measurements.

Soviets design high-frequency transducer

A magnetoelectric transducer that converts dc voltages or current input signals into high-frequency voltage is described in USSR Author's certificate 119,924. The inventors say it can accept either electrical or mechanical inputs, and may be applied as a zero indicator in automatic control systems or as a rotary transformer in computers.



It consists of two moving coils mounted on the same shaft. One is a galvanometer coil, with its loop located in the field of a permanent magnet. The second coil is located in a high-frequency field created by stationary coils which also operate as an inductance in the tank circuit of an hf oscillator.

When an input signal is supplied to the device, the moving coils are angularly displaced and a high-frequency voltage is produced. Magnitude of this voltage is proportional to the angle of rotation.

The Soviets claim the device has an unusually high conversion factor (3.1 v/degree at 220 kc with 1200 turns on the hf output coil and an effective voltage of 10 v on the oscillator circuit); also that the circuit is unusually stable.

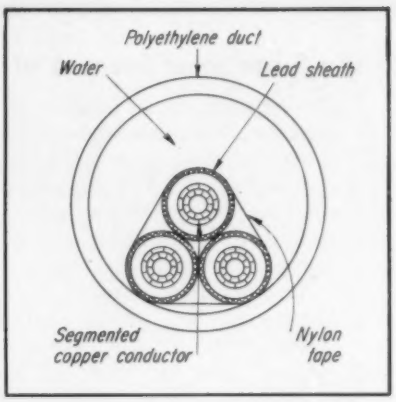
An article describing the device appeared in *Priborostroyeniye*; No 9, 1960; and a one-page abstract, in English, may be found in *Current Review of the Soviet Technical Press*, 21441-28, available from OTS, Dept of Commerce, Washington 25, DC.

continued on next page

Fatigue poses problems in cable design

First results of tests on Ontario Hydro's watercooled power transmission line (*PE—Jan 2, p 8*) indicate thermal fatigue life of the lead cable sheathing may be a limiting factor.

By cooling electrical transmission cables with water (see diagram), maximum rated current can be raised from 500 to 1400 amps; but the higher temperature of operation also puts a greater strain on the lead sheathing; and, Ontario Hydro engineers say, cracking has been found in test systems.



TRANSMISSION LINE designed for watercooling is surrounded by polyethylene. System keeps cable cool; but results in thermal cycling that may produce fatigue failure of lead sheath.

Apparently, the standard "chemical" lead is not well able to resist thermal fatigue. Better results, a survey indicates, may be obtained with tellurium and tin-lead alloys. Furthermore, it has generally been found that cyclic stresses below a specific endurance limit will not cause failure. But, says D. G. Havard of Ontario Hydro, "for lead, the existence of such a limit is uncertain because of inherent experimental difficulties and lack of sufficient data." Further studies are now planned.

Superpure aluminum readies for structural jobs

More superpurity aluminum (99.99% or better)—for applications ranging from structural metals cladding and rivets to electronic parts—is on the way.

Productive capacity in the US alone is now close to 7.5 million pounds, almost equal to the total new supply available in the US last year, and that was 74% imported. With the added supply—and the added suppliers—will come a real effort to put the material to work in electrical products, auto trim, and the other applications mentioned above. The price is still high (in the $46/lb range), but increased supplies should bring it down.

British offer improved flexible conductors

Flat copper strip, laminated between polyethylene tapes, and sealed in place without adhesives, is now being offered by Telegraph Condenser Co Ltd of London for printed circuit and other limited-space applications. A joint development of TCC and British Insulated Calendars Cables, the material is being made in two current ratings—2.5 and 5 amps. Units are available with 4, 8, 12, 18, and 26 conductors on a 0.15-in. module. Instantaneous breakdown voltage in water is "not less than 3 kv rms." Recommended maximum working voltage is 500 v ac. Top operating temperature: 160 F. Cable weight for a 12-conductor unit (1.95 in. wide) is 1.4 lb/100 ft. Special connectors designed for the cables are to be made by Belling & Lee Ltd of Middlesex.

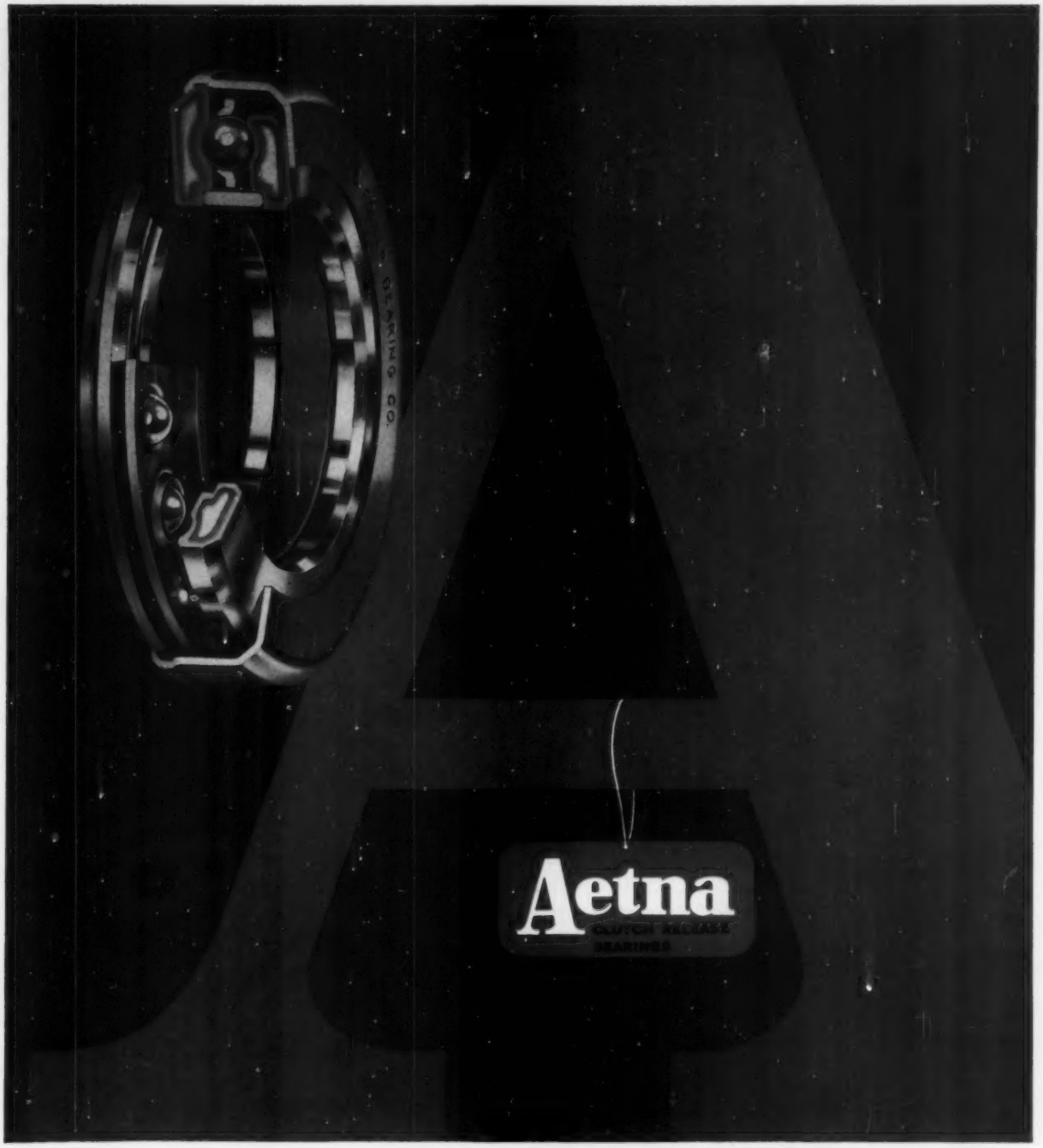
Mechanical troubles plague reactors

Stress-corrosion cracking gets the blame for two recent reactor failures, and may have to share responsibility for others.

The big Dresden power reactor is down for repairs because one control rod separated from its drive and others threatened to do so. The reason: "stress-corrosion cracking of the precipitation-hardened grade of stainless steel used in the drive tube."

The Oak Ridge Homogeneous Reactor, too, has been plagued by stress-corrosion cracking. It has been out of action twice as a result of leaks traced to this cause.

Immediate cures for the problem involve replacement of the part and changes in operating techniques. But the real solution calls for more metallurgical research and new designs. —ARG



LISTEN . . . THEY'RE SO QUIET Put an Aetna bearing to the noise test and listen. Aetna bearings are quiet. They run smoothly and silently on and on without a trace of crackling or whine. This is because Aetna bearings are sound tested under prescribed load to uncover all traces of dirt, chatter, groove wobble, tight cage, and other imperfections. Sound testing is an important part of our quality control. And it assures you of consistently dependable bearing performance for your applications. For information on the complete line of Aetna ball and roller bearings, call your Aetna representative listed in your classified directory or write for General Catalog and Engineering Manual.

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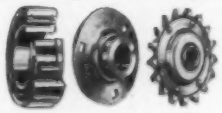

ANTI-FRICTION SUPPLIERS TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916

designing with USS High Strength Steels

Good design goes beyond material selection. Once the choice has been made, the designer's job is to take full advantage of the material's properties. Few materials offer designers as much opportunity as high strength steels.

COR-TEN Steel was developed by U.S. Steel and first used in 1933.

USS COR-TEN Steel is a name that has become a byword in design circles. It is a time-tested, high strength low-alloy steel. Structural designers welcomed COR-TEN Steel because it allowed them to pare dead weight and to lower maintenance costs. As structures, mobile equipment and machinery got bigger and bigger, dead weight became more of a problem. Even when weight could be shaved without stress problems, durability suffered. This high strength steel answered both problems.

Dead weight in stationary structures is costly; in mobile equipment dead weight requires more power to move.

USS High Strength Steels' yield points are all 50,000 psi min. compared to 33,000 psi for structural carbon steel.

Strength did it. COR-TEN brand and other USS High Strength Steels have a 50% higher yield point than structural carbon steel. They permit as much as 33% weight reduction. They have superior resistance to atmospheric corrosion and abrasion, so there is little reason to overdesign. Their fatigue and impact properties are excellent. Here is a quick look at three well-known USS High Strength Steels:

Send for the manual described at the right for a comprehensive guide on how to design with high strength steels.

USS COR-TEN Steel has a yield point 50% greater than structural carbon steel, has four to six times its resistance to atmospheric corrosion. It is used to do any one of these three things: 1) in slimmer sections to cut weight at no strength loss; 2) in equal sections to increase load-carrying capacity, cut maintenance and lengthen life; and 3) any number of combinations of 1 and 2. COR-TEN Steel also has greatly superior paint adherence and is used where a longer interval between repainting is wanted.

USS TRI-TEN Steel, with its 50% higher yield point than structural carbon steel, has superior notch toughness at low temperatures and keeps rugged equipment operating even in sub-zero weather. Its high endurance limit makes TRI-TEN Steel ideal for mobile equipment that must take repeated loading and reversals of stress. It is a natural for welded structures and bridges.

MAN-TEN Steel costs only about 20% more than structural carbon steel; TRI-TEN Steel about 36% more, and COR-TEN Steel 42% more.

USS MAN-TEN Steel also has a 50% higher yield point than structural carbon steel, and is the low-cost member of the family. Weight reduction as little as 17% with MAN-TEN Steel will save money on material cost alone. MAN-TEN Steel is a tough, durable steel and widely used in earthmoving equipment, truck frames, material handling apparatus and riveted bridges.

High strength steels represent but a few of the over 3000 grades of steel in existence today. United States Steel makes a complete line of high strength steels, as well as constructional alloy, stainless and carbon steels. Bring your design problems to us. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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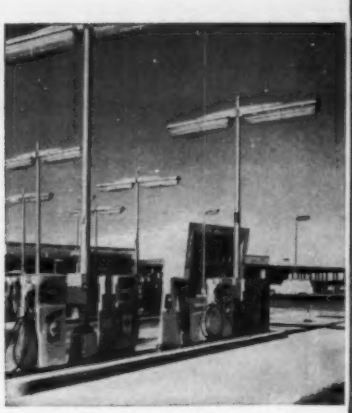
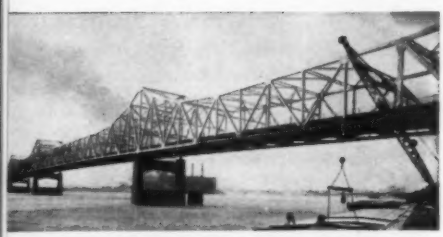
USS United States Steel

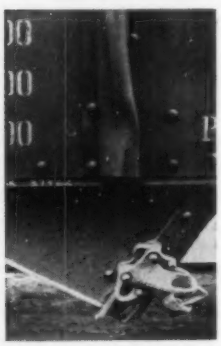
Cranes have to operate in all-weather temperatures and are subject to stress and shock. That's why many of them are made of tough TRI-TEN Steel.



Light standards stay good looking for years because of COR-TEN Steel's outstanding atmospheric corrosion resistance. Paint life is extended. Slim design is made possible by COR-TEN Steel's strength.



TRI-TEN Steel has cut weight and cost of dozens of major bridges. In the bridge shown here, TRI-TEN Steel saved a quarter of a million dollars.



One of the first applications of COR-TEN Steel was in hopper cars for weight reduction and longer life. Today, use of COR-TEN Steel can save hundreds of dollars over the life of a car.

MAN-TEN Steel, used in truck frames and body members, reduces dead weight and increases payload.

The LPG cylinder business uses considerable amounts of MAN-TEN Steel because of its strength, cost and ease of fabrication to lighten the weight.

This mark tells you a product is made of modern, dependable Steel.

Here's a book that is in the hands of thousands of engineers and designers. It is your guide to the design of lighter, stronger equipment and structures.

design manual for high strength steels

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United States Steel
Room 6151
525 William Penn Place
Pittsburgh 30, Pa.

Please send me "Design Manual for High Strength Steels"

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

WHAT'S HAPPENING IN RESEARCH...

Three-way dynamometer designed by Soviets

To measure independently the tangential, radial, and axial components of the cutting force during face milling, the Kazan Aviation Institute has designed a simple wheel-shaped dynamometer that uses a set of 3 capacitance pickups.

The unit has a central mounting hub from which 3 deflecting spokes radiate to the rim, on which the work is mounted. A tangential-force pickup is also located on the rim, at the junction point of one of the spokes. The opposite side of the rim is milled to form a flexible squirrel-cage arrangement for measuring radial and axial deflection. Capacitor transducers convert displacement to a calibrated signal for deflection in each of three coordinates, providing an independent measure for each one. A report appeared in *Stanki i instrument*, No 6, 1960.

Rare-earth compounds for semiconductor jobs

While compounds of gallium, indium, silver and bismuth alloyed with arsenic, tellurium, tin and sulfur contrive to get lion's share of research on new thermoelectric materials, rare-earth compositions are beginning to attract attention. The reason: high Seebeck coefficients and high resistivity, combined with good heat resistance.

For instance, the samarium sulfides show good thermoelectric characteristics at least to 1800 F when protected from oxidation, and their properties can be varied by changing the percentages of the two elements. A number of reports on the new materials were presented by speakers at the Joint Technical Society–Department of Defense symposium on Thermoelectric Energy Conversion, and others will be presented at meetings later this year.

briefs . . .

Semiconductor thermocouples, serviceable at temperatures to 4000 F, are to be demonstrated by Morgan Crucible Co of England at London's Physical Society exhibition next week. These are graphite and silicon carbide-graphite couples; and, Morgan says, they provide a surprisingly high voltage output. At about 1800 F, for instance, carbide-graphite units show an output of 0.2 v. Also under test: combinations of the two semiconductors with tungsten and rhenium.

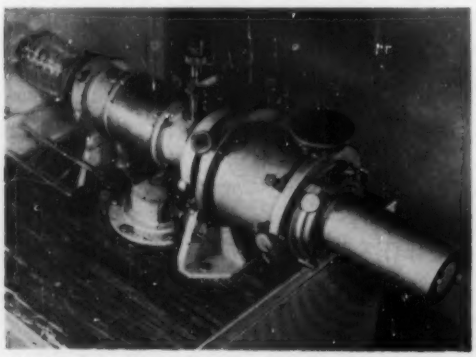
A 1/10-lb-thrust ion engine will be ready for test flight in less than two years, says Gen D. R. Ostrander of USAF. Battery power will be used at first; but by 1965 it will be converted to a nuclear power supply. The electrostatic propulsion system will use an alkali metal (probably cesium) as the ionized element, and an electron system for ion-beam neutralization. As Gen Ostrander points out, ion-beam neutralization (necessary because the ions are positively charged and charge buildup would slow down the beam if the excess were not neutralized) is one of the more difficult problems. But he believes it can be solved.

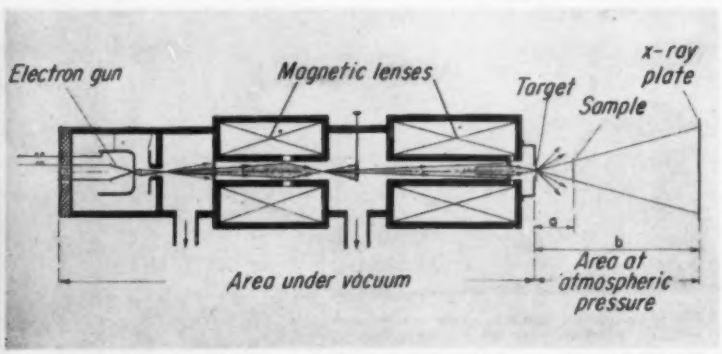
Alni magnets can be improved, East German researchers G. Ritzow and W. Ebert of VEB Hartmetallwerk (Immelborn) say, by better control of heat-treating procedures–specifically, rate of cooling. Working with non-cobalt ("alni," rather than "alnico") aluminum-nickel-iron alloys containing 4% copper, they were able to produce precipitation-hardened materials with unusually good magnetic properties. Reports on their work have appeared in *Deutsche Electrotecknik* (Vol 10, #12) and Neue Huette (Vol 4, #1). —ARG

New high-resolution X-ray microscope

A system that provides a point source of X-rays and is said to produce high-resolution (3/10 micron) pictures at magnifications of 1000 or better has been built at the Toulouse Electronics-Optics Lab of the French Scientific Research Institute.

Primary source is an electron gun whose rays are focused, with the aid of magnetic lenses, on a thin gold leaf target (see diagram). According to its developers, the device has enough depth of field so that all points–even of thick samples–appear in focus, though at different degrees of magnification. Magnification is ratio of distance between source and plate to distance from source to object (b/a).





POINT SOURCE of X-rays is formed at target by electron gun (left) in this French microscope. Though gun and associated magnetic lenses must be held under vacuum, sample and X-ray plate can be at normal pressure.

VALUE ANALYSIS FACT SHEET

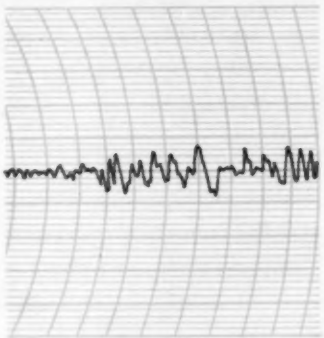
Formbrite Drawn Brass Parts

How to open finishing room bottlenecks and cut polishing costs up to 50%—produce stronger, more scratch-resistant parts—and get additional savings —with Formbrite, superfine-grain drawing brass.

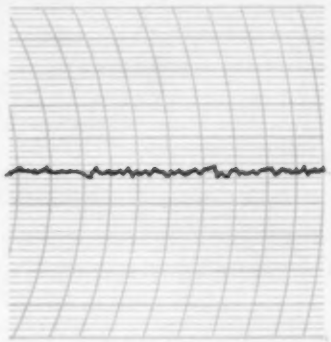
Very often in the production of drawn brass parts which are to be plated or lacquered, finishing costs are greater than those of all preceding operations —or even the cost of the metal. Under any circumstances, they are a high percentage of total costs.

Furthermore, parts go through the pressroom a lot faster than they can through the finishing room, creating bottlenecks in production.

ENLARGED SURFACE TRACES at the right prove that you can lick both cost and time problems with Formbrite®, Anaconda superfine-grain drawing brass. Savings in polishing costs reported by users run from 40 to 50%. These are net savings, as Formbrite costs no more than ordinary drawing brass.



Enlarged surface trace of standard drawing brass (grain size, .045 mm) after 40% elongation. This kind of roughness causes "orange peel" effect in the working of standard drawing brass. Smoothing such mountains down to the valleys takes considerable cutting.



Enlarged surface trace of Formbrite drawing brass (grain size, .005 mm) after 40% elongation. Surface smoothness after deformation is the test of a drawing brass's polishing characteristics. It is relatively easy to level these little hills on the surface of Formbrite. In many cases, users find they eliminate cutting operations altogether, need only a simple color buff.

STRONGER, MORE SCRATCH RESISTANT. Formbrite is stronger, harder, springier than the usual drawing brasses in the same standard tempers, yet retains remarkable ductility for forming and drawing, and takes sharp, clean-cut ornamental die impressions. The harder surface means fewer rejects from scratching and marring during handling. In some instances, the superior strength and hardness of Formbrite make possible the use of a thinner gage metal, with an additional saving in material cost.

This is the microstructure, shown 75x, of the standard drawing brass used above.

This uniform superfine-grain structure of Formbrite, shown 75x, is produced by special procedures for rolling or drawing and annealing developed by Anaconda American Brass Company.

SIZES AND TEMPERS. Brass manufactured by the Formbrite method, with its special characteristic of superfine-grain structure, is supplied in standard Formbrite temper, half-hard, three-quarter-hard, hard, and extra-hard tempers, and can be rolled in heavy coils to .004" in thickness by 24" wide, weighing 100 pounds per inch of width. The table below gives physical data and terminology for Formbrite tempers.

ALLOYS. In addition to 70-30 brass, the following Anaconda alloys also are produced by the Formbrite method: Yellow Brass-59, Gilding Brass-4, Commercial Bronze-14, Red Brass-24, and Low Brass-32.

TECHNICAL ASSISTANCE. For help in selecting the alloy and temper to handle your particular job—for a copy of Publication B-39 with more details about Formbrite—see your Anaconda representative. Or write: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6145

TERMINOLOGY FOR FORMBRITE TEMPERS

TENSILE STRENGTH LB. SQ. IN.		ROCKWELL B HARDNESS		DESIGNATION TO BE USED
MIN.	MAX.	MIN.	MAX.	
49,000	59,000	40	65	Yellow Brass—Formbrite
57,000	67,000	60	77	Half-hard Yellow Brass—Formbrite
64,000	74,000	72	82	Three-quarter-hard Yellow Brass—Formbrite
71,000	81,000	79	86	Hard Yellow Brass—Formbrite
83,000	92,000	85	91	Extra-hard Yellow Brass—Formbrite

FORMBRITE

Superfine-grain drawing brass

a product of

ANACONDA®

Anaconda American Brass Company

CIRCLE 11 ON READER SERVICE CARD

CIRCLE 12 ON READER SERVICE CARD→

PHOTO MATERIAL COURTESY OF WOODALL INDUSTRIES, INC.

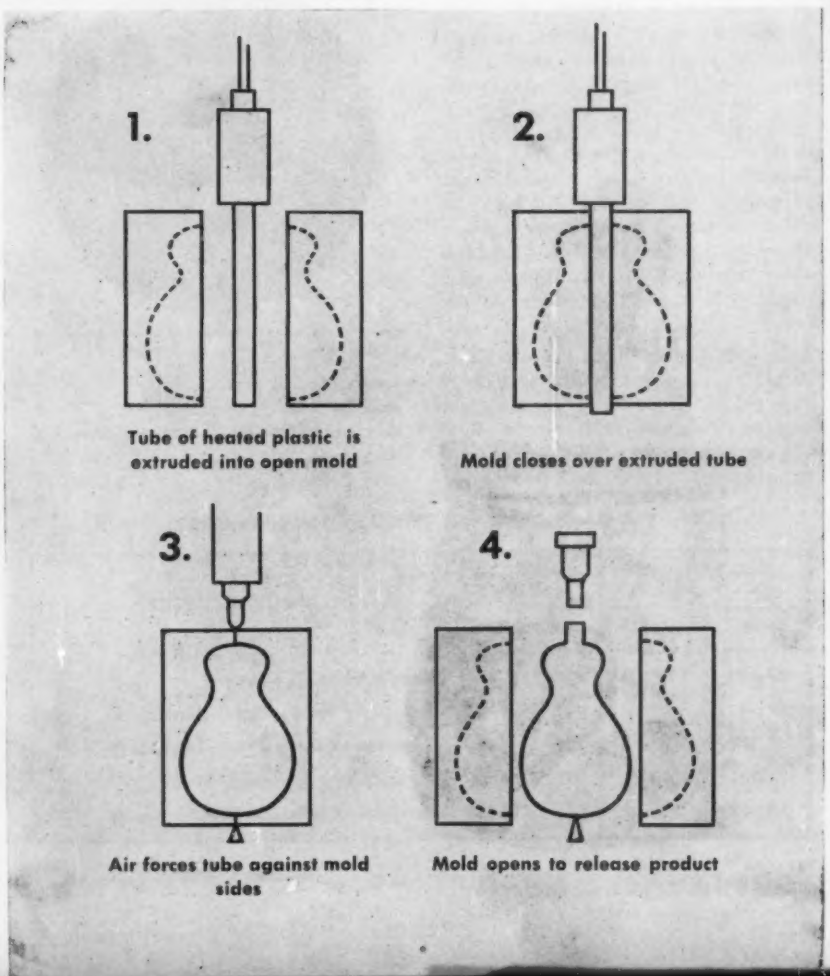
The auto industry warms up to blow-molded polyethylene

These complex shapes you see are sections of heater ducts for Chrysler Corporation cars, blow molded of BAKELITE Brand high-density polyethylene. Each part is made in *one piece*. These components must fit together easily and precisely, yet this method produces them economically. They are tough and light-weight, characteristic of the material from which they are made. They show the designer new sizes and shapes he can now work with in polyethylene.

BLOW MOLDING PUTS BIG DESIGNS

Blow molding is economical

Economy is a major advantage of the blow molding process. All you need is the mold cavity; the core is air pressure itself. Essentially, the operation begins when an extruded tube of heated plastic is placed within the two halves of a mold. An air blast into the tube forces it out against the mold, which is then opened, allowing the blown piece to be removed. Since air pressures seldom exceed 80 psi, molds can be made from low-cost materials and tooling up is fast. The plastic is formed at relatively low temperatures. That means faster cooling. Refinements of the basic process allow cost-cutting automation. Even injection molding equipment can be adapted to the process for special requirements.



50% cost reduction was just one of the benefits...

This traffic blinker housing is two feet long. It, too, is made in *one piece* by blow molding high-density polyethylene. Any other technique would have required a two-piece assembly. Previously constructed from sheet metal stampings, it required not only assembly but a separate coating operation as well. Blow molding saves 50% of former production costs! Molds can be made quickly and inexpensively. The color is molded in. BAKELITE Brand high-density polyethylene also gives the product lightness, rigidity, and durability.

IN PLASTICS

Since participating in the development of the squeeze bottle, Union Carbide has been refining the techniques and materials for blow molding. Facilities for studying production-line blow molding at the Bound Brook, N. J., laboratories are unsurpassed. A battery of blow molding machines there reproduces every set of conditions encountered in the process. This equipment, in addition to providing basic knowledge about blow molding, helps in developing new BAKELITE Brand polyethylenes—high-, medium-, and low-density, and copolymers. You can select from the greatest variety available at one source, confident of getting the formulation best suited to your needs.

For information on application of these materials and processes to your products, write Dept. IN-113, Union Carbide Plastics Company, Division of Union Carbide Corp., 270 Park Ave., New York 17, N. Y. *In Canada,* Union Carbide Canada Limited, Toronto 12.

UNION CARBIDE

BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

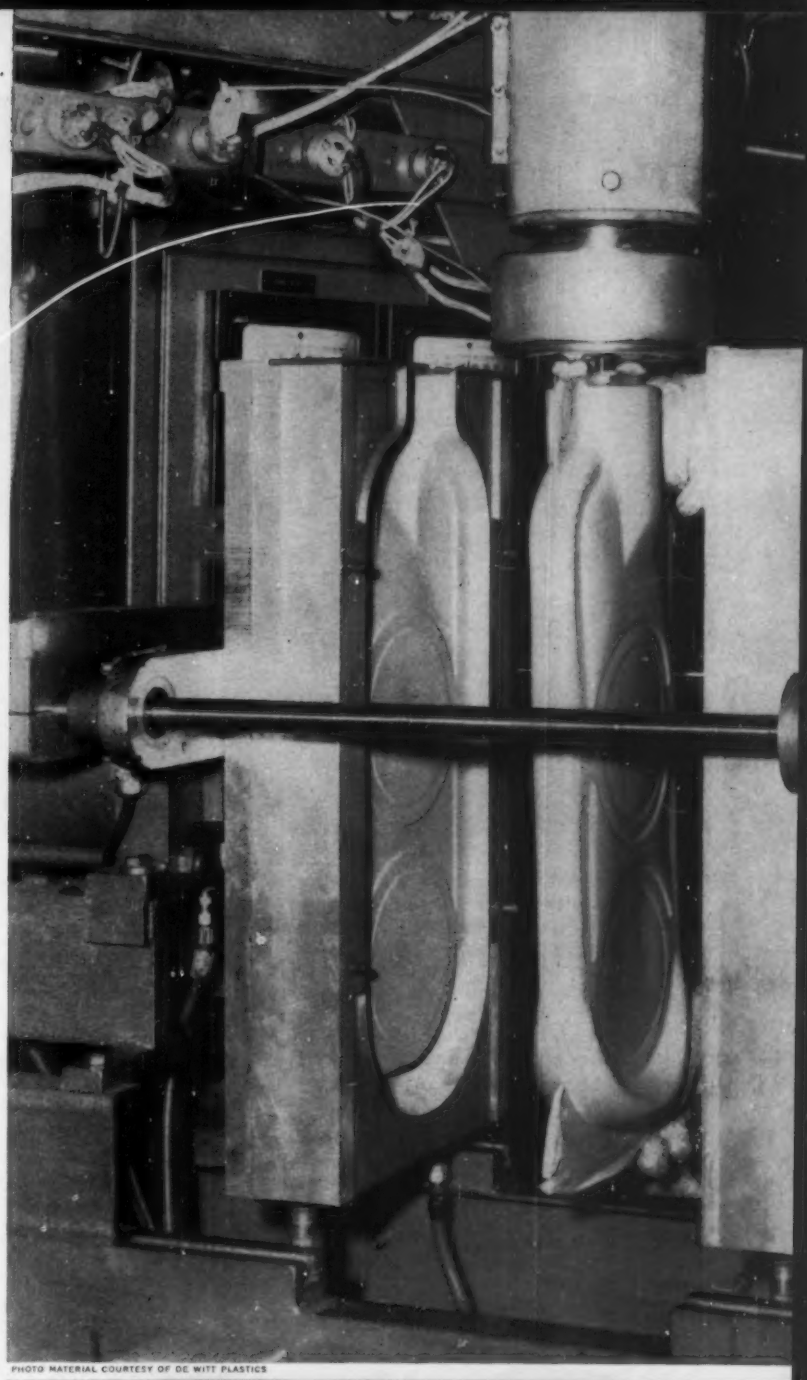
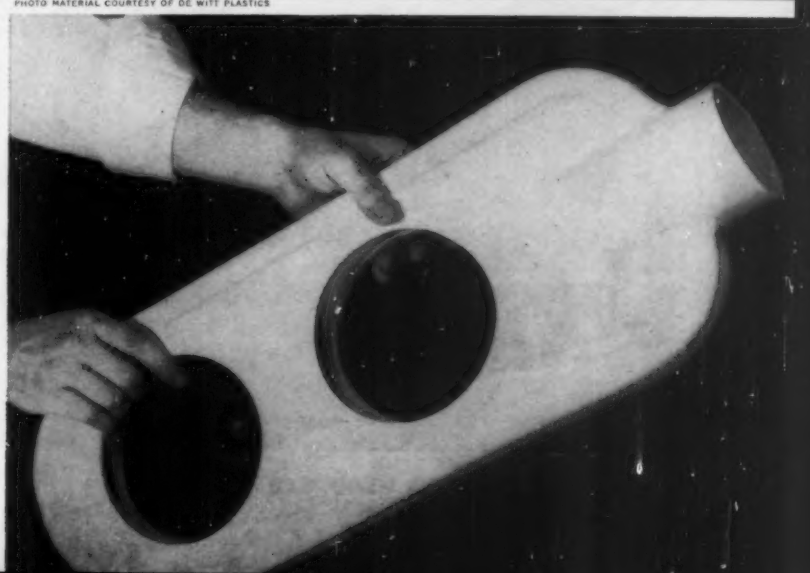
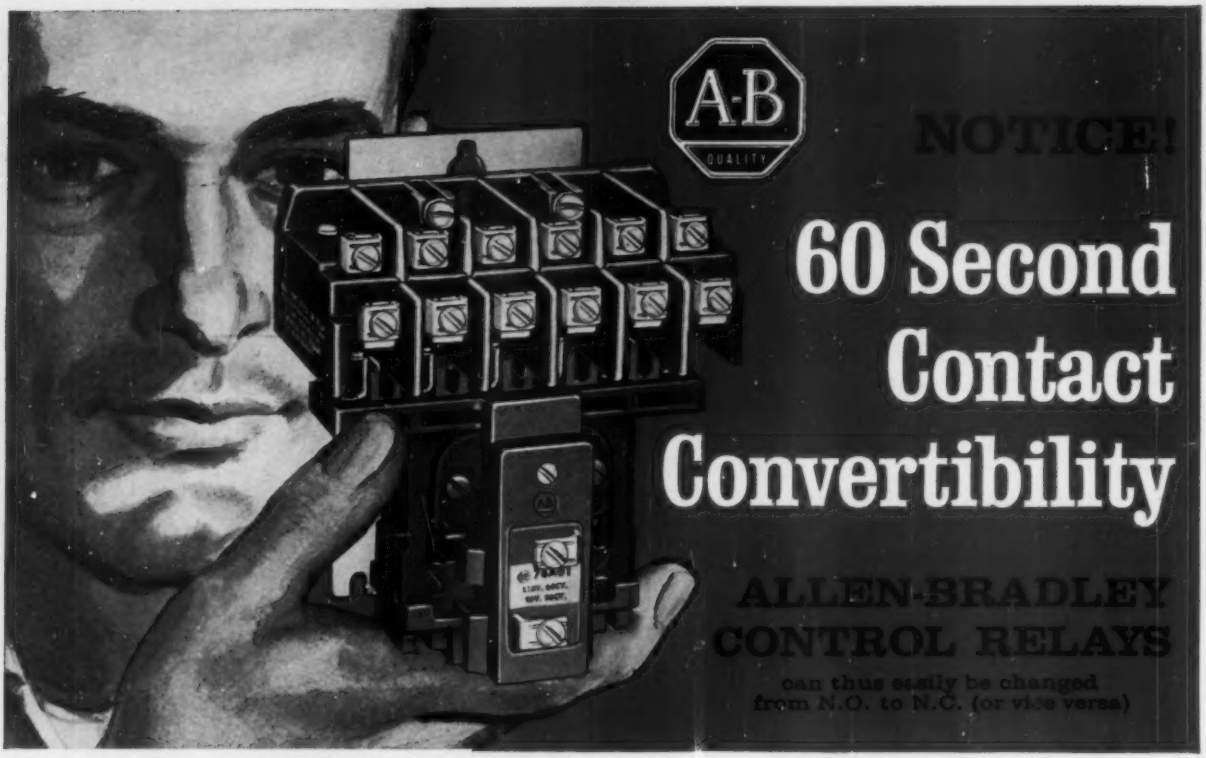


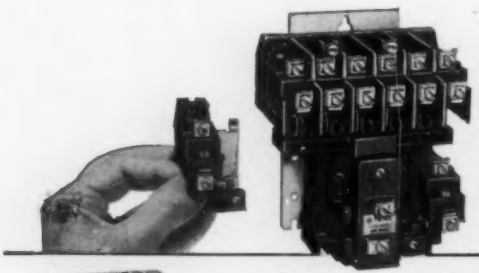
PHOTO MATERIAL COURTESY OF DE WITT PLASTICS





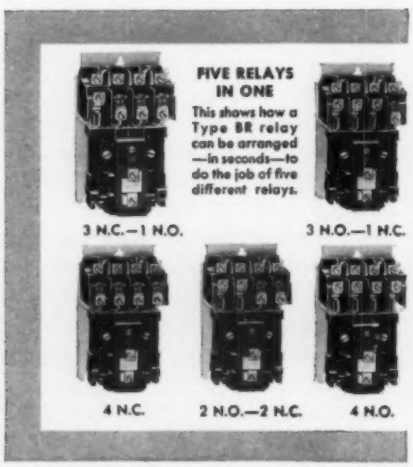
Why not give yourself a real surprise! We refer to the ease with which you can convert the contacts of these Allen-Bradley Bulletin 700 Type BR control relays. Using only a screwdriver, contacts can be changed from normally open to normally closed (or vice versa) in seconds—without removing the relay from its mounting—or its wiring. This "on-the-spot" convertibility certainly suggests an appreciable moneysaving reduction in your relay inventories.

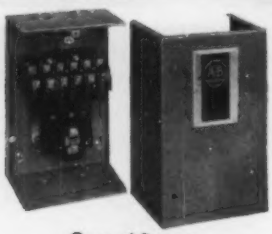
Extensive tests have proven conclusively that the Bulletin 700 Type BR relays are good for many—and we mean *many*—millions of trouble free operations. A "built-in" permanent air gap completely eliminates all possibility of magnetic sticking. Naturally, the double break, silver contacts never need attention. Also, the molded coil is your assurance that even the most severe atmospheric conditions cannot cause trouble. Please write for full details on these relays today!



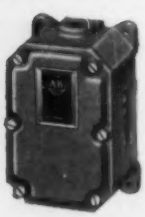
BUT HEAR THIS!

In the event that when "on-the-job" it is discovered that something was either overlooked or added, the standard Bulletin 700 Type BR—either 2, 3, 4, or 6 pole relay—can easily have added to its base, out in the field, either one or two switching poles. It is done as easily as "falling off a log."


FIVE RELAYS IN ONE
This shows how a Type BR relay can be arranged—in seconds—to do the job of five different relays.
3 N.C.—1 N.O.
3 N.O.—1 N.C.
4 N.C.
2 N.O.—2 N.C.
4 N.O.



General-Purpose
NEMA 1



Explosion-proof
NEMA 7

Waterproof
NEMA 4

ALLEN-BRADLEY

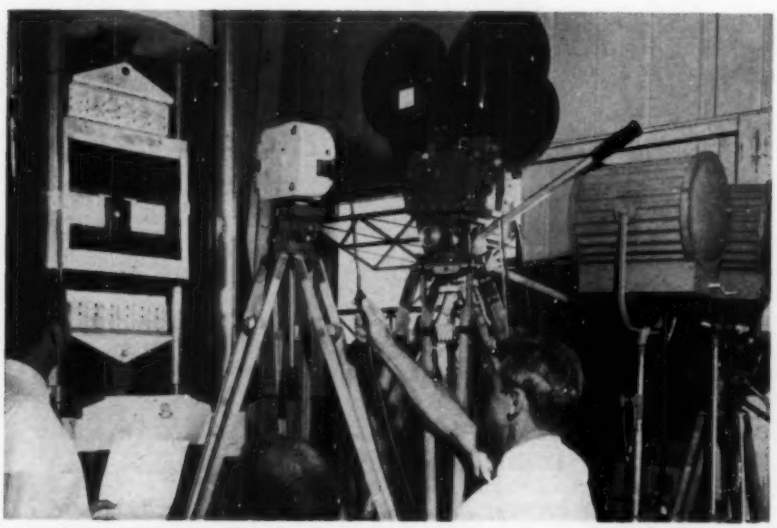
Member of NEMA

Allen-Bradley Co., 1329 S. First St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY MOTOR CONTROL

THE ENGINEERING WEEK

MOTION PICTURE SETUP of normal type has an Auricon Pro 600 camera to record the strain distribution in a spotwelded tensile specimen. Box containing a polarized filter has been taped to light source. Black rectangle behind specimen is plate to supply a dark background and allow photographing of specimen from both sides through a slot cut in the plate. Most difficult problem is elimination of light reflection on the relatively shiny surface of the plastic coating. Any medium-speed color film is satisfactory.



CRACK-PROPAGATION study has four cameras (two Auricon Pro 600s, one Arriflex, and a 400-frame-per-sec Milliken DBM-5) to record all phases of a 2024-T3 aluminum plate test. One Auricon is directed at each of the two rectangular pieces of photoelastic coating; the Milliken operates only at the estimated beginning of the fast crack; and the Arriflex records the over-all crack propagation. Because of the multiple photo coverage and heat of the lights, a sheet of circularly polarized plastic (in frame) is placed over the specimen. This method is vulnerable to glare at surface of the polarized sheet. Operator of the testing machine calls off the applied loads for recording on the film of the Auricon camera. (Permanent strain is shown in picture at right).

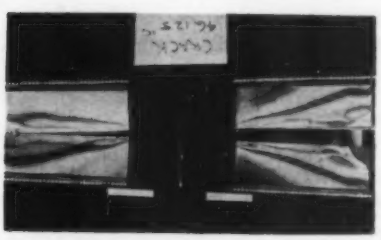
Motion Pictures Aid in Stress Evaluations

SAN DIEGO—A vexing problem has been solved for users of photoelastic coating techniques (PhotoStress) for dynamic loading conditions. The problem: how to evaluate the color distribution changes before the color stress pattern in the test dissolves. The answer: color photography — either normal or highspeed motion pictures —with or without sound.

The techniques were developed by W. E. Witzell, senior test laboratory engineer, and C. DeMond, photographic specialist, of General Dynamic Corp's Convair (Astronautics) Div, here. By using professional-type motion picture cameras and lights with polarized filters, the entire range of a dynamic load test can be viewed. This permits analysis of load variations that might be missed in visual viewing.

DeMond and Witzell point out that the normal variables of photography—light source, film and exposure —are further complicated by introduction of a double filter factor. A polarizer must be placed over the light source and a second one over the camera lens, and both properly oriented to photograph the stress pattern. However, the value of the complete load test more than compensates for the additional problem. Circularly polarized plastic sheets are obtainable from the Polaroid Corp. of Cambridge, Mass.

The only real trouble, says Convair, is the need for professional-type motion picture equipment—and this is mostly a cost problem. They recommend use of a "through the lens" fo-



PERMANENT STRAIN in fractured 2024-T3 specimen. Portions of the photoelastic coating broke off adjacent to the crack at the fast fracture of the aluminum. Specimen was tested to failure to study both slow and fast crack propagation.

cusing and framing system on the camera. The areas to be photographed are usually small and external viewing systems are ineffective at close range. Data-reduction equipment is not a problem, according to Witzell and DeMond. Where sound is used, the only special requirement is a sound projector. Under other circumstances any normal projector that permits normal speed, slow motion, or frame-by-frame viewing on a regular screen is sufficient. For careful study, a special frame-by-frame projector is needed. ■

Progress Reported in Powder Metallurgy

DETROIT—A number of advances in techniques for producing powder metallurgy parts were reported here at a seminar for the benefit of automotive engineers. Trend is definitely to larger, more complicated parts; a number of parts in the 2-lb range are now being produced.

Iron parts made from powdered metal are serving as inserts in aluminum diecastings, surface porosity of the sintered parts permitting infiltration of the aluminum to give a mechanical bond.

Alloying additions (mainly nickel and molybdenum) to iron powders produce parts with ultimate tensile strengths in the 75,000 to 100,000-psi range. Close process control now permits production of steel parts to specified carbon ranges.

Copper infiltration of low-density iron parts gives strength in the 60,000 to 75,000-psi range. Infiltration of sintered steel parts brings strength up to 100,000 psi. This can be upped to 180,000 psi by heat treatment. Copper infiltration is also called on to make composites out of two or more parts, some of which may have been made by other than powder metallurgy processes.

One post-treatment discussed uses steam to harden parts by controlled oxidation. Surfaces of a part can be made file-hard (about Rockwell C58) by this process. Effect of steam-treating on internal hardness varies with density of part. Induction hardening often permits selective hardening of parts to give surface hardness while maintaining desired softness of cores and hole bores.

—Felix Giordano, Regional Editor

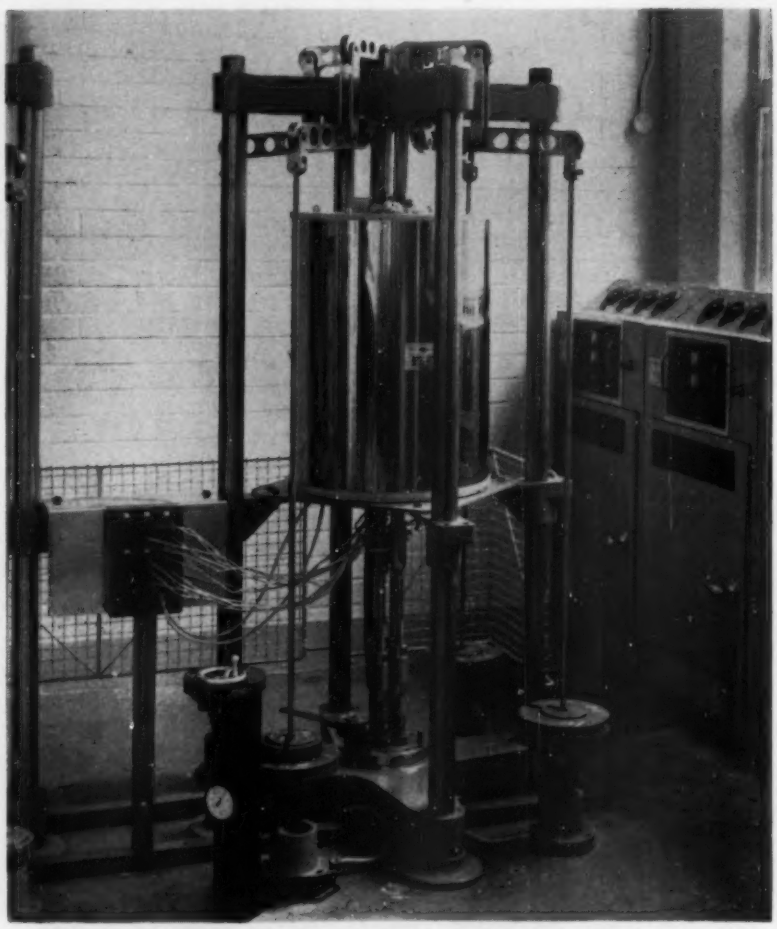
Corrosion Cracks Show Up on British Turboprop

LONDON—Britain may have forestalled a rash of turboprop airline accidents by discovering corrosion cracks in the wing spars of the Viscount 700 airliner. These early Viscount models have magnesium spars; later models switched to a copper-containing alloy with a lower tensile strength but better fatigue characteristics.

The magnesium alloy involved was dropped by all British manufacturers as a primary-load carrier nearly three years ago because it tends to fret and has poor fatigue characteristics. This accounts for the fact that only the early Viscounts are affected by the current checkup. Life of the magnesium components was accordingly limited and old spars replaced by new ones at a specified flying-time interval.

Cracks appeared in two of four Viscounts operated by Central African Airways in the lugs of the main spar joint between the inner and outer

Handy for Creep Testing



Compactness is featured in this multispecimen testing machine designed by The United Steel Co Ltd, Sheffield, Eng, and being built by the Distington Engineering Co Ltd, Workington, Northumberland. Terminal box (left) is for thermocouple connections. The lifting jack (left foreground) is one of two auxiliaries supplied with the machine. Battery of control consoles (right) regulates individual machines. The unit is essentially a frame, top and bottom castings with four columns, supporting four individual lever systems with loading weights. Weights exert a tensile load on a string of rods and links incorporating the specimen. As the specimen slowly extends, the weight descends until maximum descent occurs. Weight is then raised by the jack which unloads the specimen. Slack is taken up by a portable ratchet gear and load reapplied by lowering the jack. Graduated dial on jack reloads the specimen at any predetermined rate. Furnace gives even heat around the specimen, allows elevated-temperature testing.

wing sections. Vickers metallurgists are at a loss to explain the cracks, but emphatically declare they are not caused by fatigue.

Corrosion is clearly a factor but this confuses the issue, as at least 100 other Viscount spars of the same material have been routinely examined at the Vickers-Armstrong Weybridge plant without any signs of corrrosion or fatigue. These are spars that have been removed from 700-series airliners at the expiration of their useful life as set by the British manufacturers. Also, additional stress-cycling tests under simulated conditions on time-expired spars positively demonstrated the adequacy of the life adopted.

One cause of the corrosion now being investigated is defective protective coating caused by poor processing. In the meantime, Vickers has notified some 13 operators of some 80 early Viscounts to restrict indicated airspeed to 150 knots and examine all wing joints within seven days. Ultrasonic inspection is required. ■

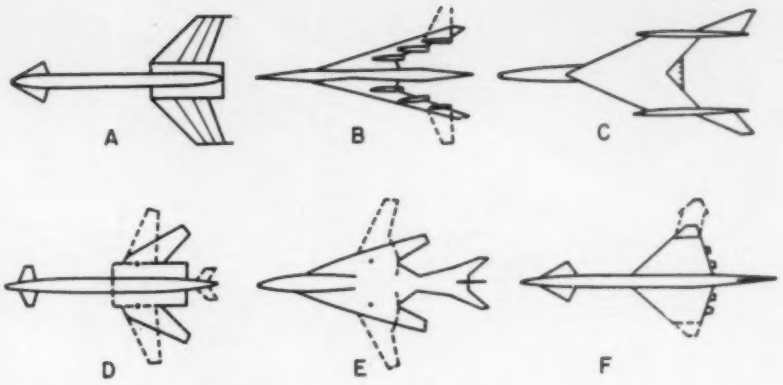
Soviets Speed Development of Air-cushioned Vehicle

Moscow—According to reports here, designs for an air-cushioned amphibious passenger craft have now been completed by the Central Technical Construction Bureau of the Ministry of River Fleets in Leningrad. The reports are not clear on whether an experimental model has been made.

Outwardly resembling an amphibious motorcar, the river vehicle derives lift from two horizontal aviation-type engines and forward propulsion from a third engine behind the passenger cabin. A tailfin and rudder, apparently set behind the propulsion engine, provide guidance and stability.

The craft reportedly can carry 38 passengers over water, sand bars or beaches at 34 mph. It is expected to be about as cheap to operate as a hydrofoil and somewhat more versatile. Hydrofoils are now under intensive development in the USSR.

Articles appearing elsewhere in Soviet publications suggest that air-cushioned vehicles may be developed for transportation in the steppes or tundra regions where roads are poor or nonexistant. These vehicles, according to some proposals, would have elliptical or saucer-shape bodies.



FAA Chief Stresses Need for 2000-mph Jet Airliner by '68

WASHINGTON—The Federal Aviation Agency says the US has the technical ability to put an economically competitive supersonic jet airliner into the air by 1968 or 1970, and urges that a joint government-industry development program be started immediately.

FAA Administrator Elwood R. Quesada, in one of his last recommendations before leaving office with the change of administrations this week, says a 2000-mph airliner would open a "new era in world travel." He estimates the development cost at $500 million and the Free World market for such a transport at 200 planes, about two-thirds of which would be bought by American air lines.

UK, USSR ALREADY BUSY

Quesada, in a report to the President and Congress, says Russia and Britain already are at work on a supersonic airliner and that the US cannot afford to sit out the race. Prestige and national defense requirements (the airliner could be used for transporting troops quickly to world trouble spots) dictate US production.

He says production would bring about important economic benefits by keeping alive the plane-building industry, holding down unemployment, and helping maintain a healthy balance of payments through export sales and increased tourism.

In the 57-page report, the FAA chief also discusses design requirements and problems. These are complicated by the fact that the airliner must be able to operate from existing airports, with flight efficiency and direct operating costs comparable to existing subsonic jets.

Based on current design concepts, takeoff gross weight would probably be in the 350,000 to 400,000-lb range. The plane would climb at subsonic speeds to about 45,000 ft and then accelerate to supersonic speeds. The acceleration and climb would continue to cruise conditions—Mach 3 at 65,000 ft.

At start of the cruise phase, the aircraft would have been airborne for about 20 min., would have traveled about 250 mi and used about 30% of its fuel. The supersonic cruise portion would last about 100 min. and consume about 50% more of the fuel. Letdown and landing would require about 30 min.

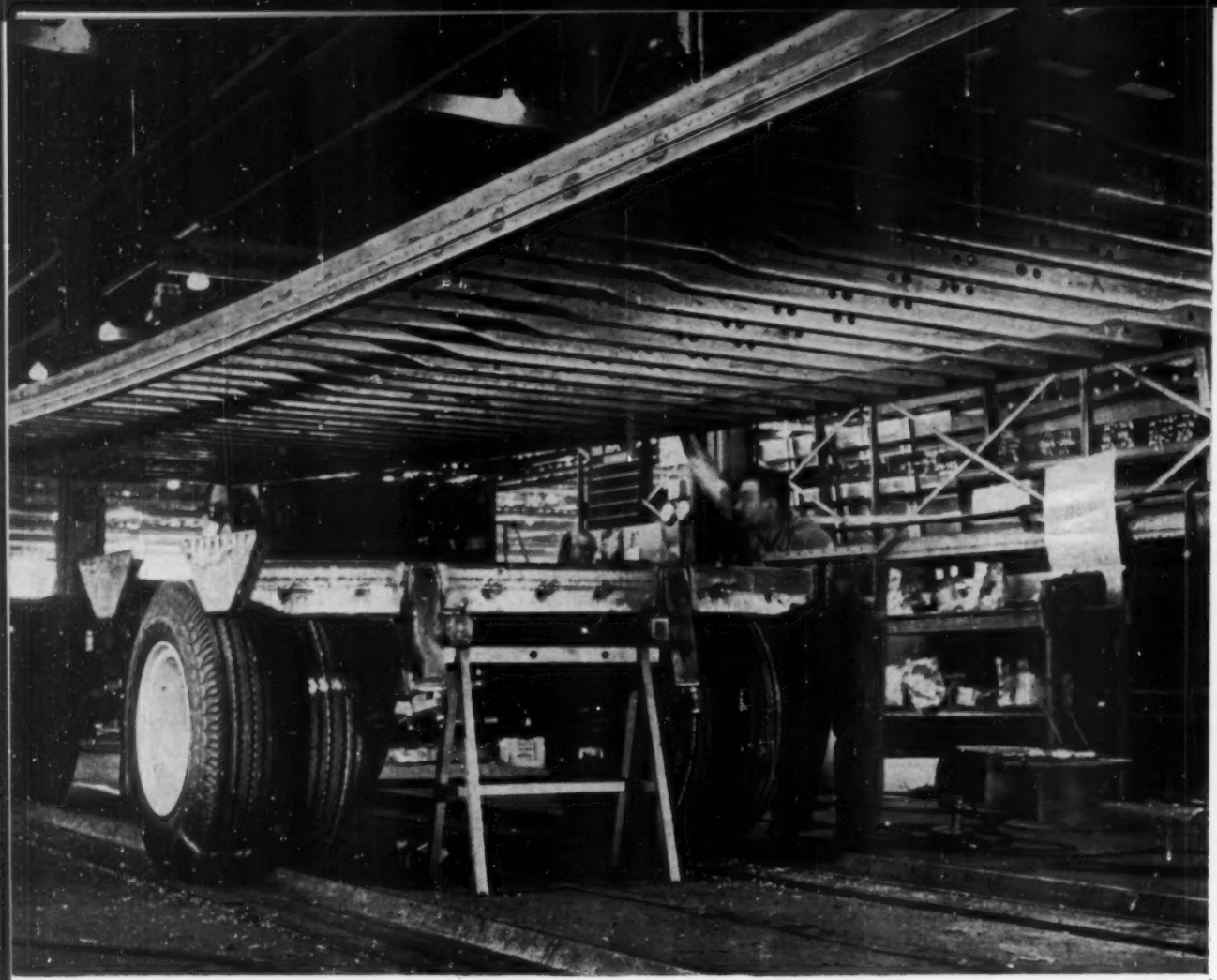
"The currently specified fuel reserves are substantial and can result in reserve fuel at landing equal to the payload of the aircraft," the report says. "This, of course, constitutes a severe performance penalty."

As for airframe configuration, the supersonic plane must be able to attain higher usable lift coefficients if it is held to present jet takeoff and landing speeds. The report says this can be solved by using wings of higher-aspect ratio. (Illustrations above.)

Quesada says both turbojet and turbofans appear capable of powering the plane, but indicates a co-burning turbofan, with improvements, would be the best bet. This type of engine, he says, would use the least fuel during a complete mission, having the lowest takeoff noise level and provide the smallest airplane size.

"Acceleration altitude with this engine configuration, however, is below that for the six-afterburner turbojet configuration; and further research and development will be required to attain

continued on page 20



At Fruehauf Trailers' huge Avon Lake, Ohio, plant, crossmembers made from PITT-TEN high strength structural sheet provide 22 percent more payload.

Here, on the assembly line, a Fruehauf trailer bed made with Pittsburgh Steel Co. PITT-TEN is swung onto the underconstruction assembly.

As Trailer Bed Crossmembers

Fruehauf Gets 22% More Payload With Pittsburgh Steel's New PITT-TEN

Twenty-two percent more payload—that's what Fruehauf is building into the framework of giant trailers assembled with crossmembers made of PITT-TEN, Pittsburgh Steel Company's new high strength structural sheet.

Fruehauf uses PITT-TEN #1 at its Avon Lake, Ohio, plant—the largest trailer manufacturing facility in the world—because it offers a combination of benefits that . . .

- **Cuts deadweight with no loss of strength**
- **Lengthens service life through superior corrosion resistance**

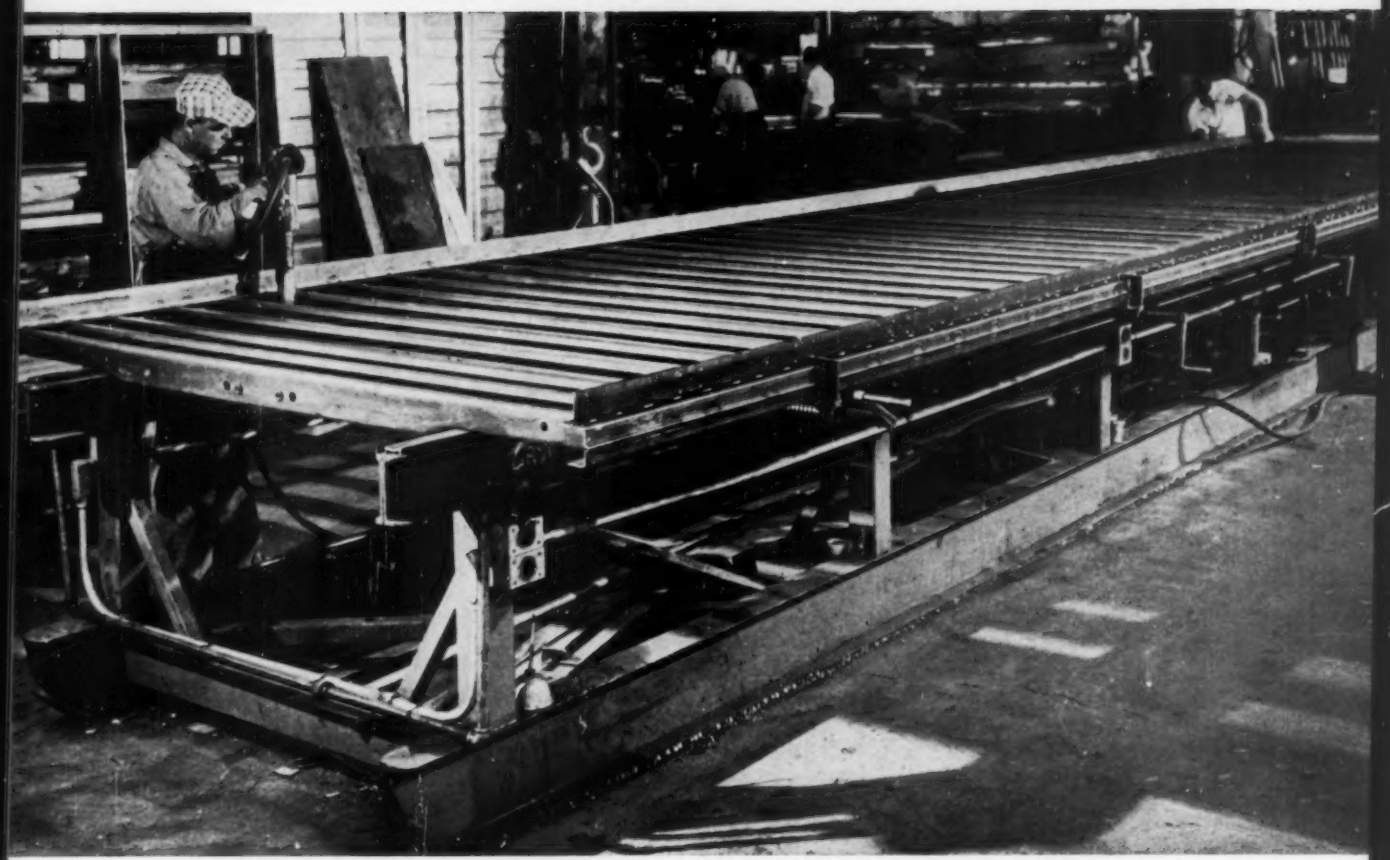
• **Light Yet Strong** — Fruehauf tries to make its trailers as light as possible with no sacrifice in strength. Trailer bed crossmembers made of high strength PITT-TEN are lighter, for equal strength, than mild steel.

The weight saving amounts to more than eight pounds for each piece. That's because three pounds of PITT-TEN do the work of nearly four pounds of ordinary sheet steel. At the same time, it provides all the strength needed for years of hard use.

Corrosion resistance is another problem in trailer operation. Fruehauf trailers are used under all types of conditions that could create maintenance headaches if the proper material were not used.

PITT-TEN #1 has four to six times the resistance of carbon steel to atmospheric corrosion. So, Fruehauf specifies PITT-TEN to reduce maintenance costs.

The trailer part basically is a channel 93⅛ inches long, 2 inches deep and 3 inches wide. Its width is expanded to 4½ inches on one side by an offset that extends most of its length. In addition, a ¼-inch



During assembly of Fruehauf trailer bed, cross-members made from high strength structural PITT-TEN are riveted to the side rail. PITT-TEN #1 reduces maintenance requirements of Fruehauf trailers through superior corrosion resistance. It has four to six times the corrosion resistance of carbon steel to atmospheric corrosion. PITT-TEN also cuts deadweight with no loss in strength.

return flange is applied full length to both edges.

Fruehauf engineers point out that forming this piece with offset and flange in high tensile steel would be a tricky business without consistent quality — and with PITT-TEN Fruehauf has a steel that does the job.

PITTSBURGH STEEL NEW SOURCE – This is one of several applications which mark the entry of Pittsburgh Steel in the high strength steel market, one of the fastest growing in metalworking.

That means this:

Fabricators of high strength steel structurals—or any product where the weight/strength ratio is a factor—now have a new source of supply.

In the eight years Pittsburgh Steel has been producing flat-rolled products, it has become recognized for the unexcelled quality of its steel sheet and strip. Now PITT-TEN is being produced by the same fine steelmaking and steel rolling facilities which have earned that reputation for quality.

PITT-TEN is produced in three grades, each with specific physical properties. Briefly, here they are:

PITT-TEN #1—An all-around high strength structural sheet that offers a combination of benefits. First is greater strength without increased weight; or equal strength with a lighter section. Second is longer product life, less maintenance through greater resistance to corrosion (four to six times that of mild carbon steel.)

PITT-TEN #2—high strength sheet with exceptional formability. This grade is produced to tensile and yield requirements to meet forming problems of specific fabricated parts.

PITT-TEN "X"—produced to guaranteed minimum yield points of 45,000 and 50,000 psi. This grade is especially useful where the controlling factor is a reduction in weight without loss of strength.

If your product's success depends on weight/strength factors, then Pittsburgh Steel's new PITT-TEN can benefit you, too.

Let one of our service metallurgists show you how. They're as familiar with steel fabricating problems as they are with steelmaking problems. Just contact one of the sales offices listed here.

Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

DISTRICT SALES OFFICES

Atlanta	Cleveland	Detroit	Los Angeles	Pittsburgh
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			Philadelphia	Warren, Ohio

CIRCLE 19 ON READER SERVICE CARD

continued from page 17

the much higher degree of augmentation that is theoretically possible," the report adds.

It says turbojets with afterburners are unacceptable because of the noise problem and calls for research on whether suppressors can be developed to cut the noise level to that of present jets without a substantial penalty in nozzle weight and efficiency. Turbojets without afterburners would require augmentation on takeoff.

Aside from having a low ground-noise level, the engine must be capable of accelerating the plane through the transonic range at 45,000 ft or higher and then continue the acceleration along a climbing flight path steep enough to eliminate subsequent intensification of sonic-boom overpressure on the ground.

The report says considerable pioneering work has been accomplished by the military on structural design and materials selection for supersonic planes, but that more detailed study, testing and evaluation will be needed, primarily as a result of the high temperature of supersonic flight. Military aircraft are designed for a service life of but a few thousand hours, whereas the design configuration of the airliner must be on the order of 35,000 hr.

The report says average temperatures over the wings and fuselage for Mach 3 flight at 70,000 ft would lie in the range near 450 F with local temperatures approaching 600 F.

Incomplete test data, it says, indicate aluminum could not be used in supersonic flight above Mach 2 because its strength falls off rapidly at temperatures generated by higher speeds. But it says steel and titanium alloys show no significant loss in strength for temperatures in the 500-F range as far as these test data showed.

–Herbert Cheshire,
Washington News Bureau

Nuclear Powerplant Explosion Still a Mystery

IDAHO FALLS, IDAHO—The Atomic Energy Commission theorizes that the recent explosion in its National Nuclear Reactor Testing Station, which claimed three lives, was chemical in nature and most likely caused by a reaction between aluminum components and hot water. But investigating agencies currently applying a fine-tooth comb to the area won't know for sure for several weeks.

According to an AEC doctor, the force of the explosion blew radioactive materials into the three victims. He said that physical injuries resulting from the explosion actually killed the men, but that the radiation they received would have been fatal too.

There was no evidence of external damage to the reactor building and radio-active contamination was almost entirely contained within the edifice, which was so radioactively "hot" that only one of the three bodies could be recovered immediately after the blast. Inside this building are the reactor (being developed as a portable source of electric power and heat for the armed forces) and the water in which it's immersed; these are capped with a metal cover through which fuel and control rods run to reach the enriched uranium core of the reactor.

At the time of the explosion, the three technicians, who were the only personnel on duty in the SL-1, were thought to be connecting up the reactor control rods preparatory to a startup of the reactor after 10 days of shutdown for insertion of wires measuring power distribution.

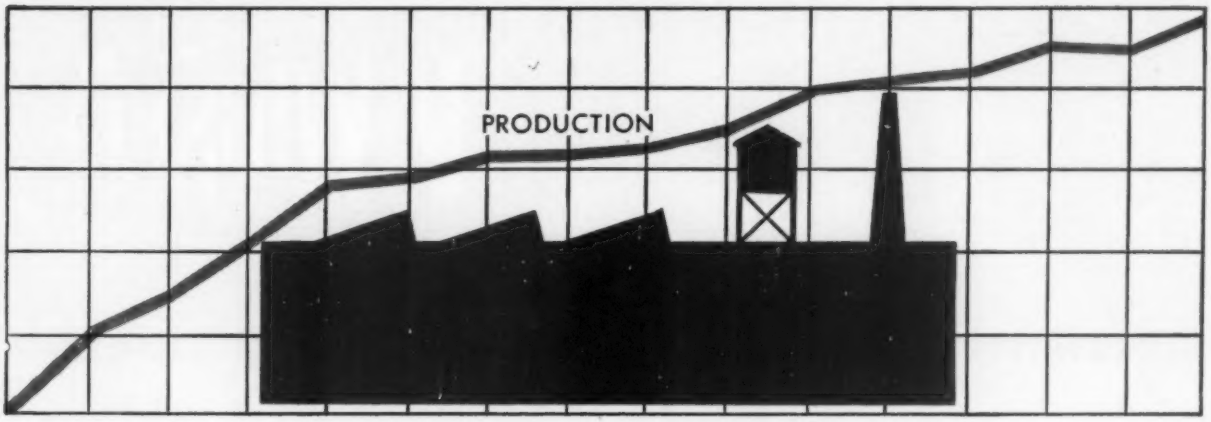
The AEC has since sealed off the area, preventing any danger to other parts of the station or to Idaho Falls, a city of 34,000 about 40 mi away.

This first fatal accident to occur in the US during 15 years of building about 150 reactors came at a bad time for proponents of municipal nuclear power. The question of safety regulations regarding location of nuclear power plants is being considered by both the AEC and the Joint Congressional Committee on Atomic Energy.

The big question being put to legislators is: Has state of the art of building atomic power stations progressed enough to locate them in or near a metropolitan area? If it hasn't (and the explosion here doesn't recommend it), then legislators are certain to demand that nuclear power be kept away from populated areas. This would work a hardship on nuclear-power producers, who are getting stiff competition from conventional power stations. ■

Shiny New—Final Assembly for Centaur's Launch-booster

Booster stage for the Centaur launch vehicle undergoes final assembly at the Convair Div plant of General Dynamics Corp in San Diego. The booster airframe (just beyond the missile in foreground) is identical to the Air Force Atlas missiles in the adjoining docks—except that its 10 ft dia is constant, not tapered at the forward end. This constancy gives the Centaur booster added fuel capacity. Centaur's upper stage will be powerd by Pratt & Whitney liquid-hydrogen engines. NASA plans to launch the first Centaur at Atlantic Missile Range in about six months.



How to expand without added expenditure

Right away let's make this point clear: you won't find any magic formula here for expanding your plant physically at no cost. What you *will* find are facts about a material that can definitely help expand your plant's productivity . . . and your product's salability.

That material is Masland Duran Clad, the new semi-rigid vinyl for laminating to metal sheets or coils according to your specifications . . . the built-in finish that obsoletes dipping, spraying, brushing, coating and similar finishing methods . . . the vinyl-to-metal laminate that can even do away with the need for having a finishing department.

Think what this can mean in terms of expanded productivity. Space now devoted to finishing operations can be used to expand your production area. Money currently spent in equipment, maintenance and finishing supplies can be channeled to more productive use. Costs of rejects, and the insurance costs of handling explosive materials can be eliminated, too, since Clad enables you to work with *prefinished* parts.

Consider, too, what Clad can mean in greater sales potential for your product. This durable, decorative vinyl can be produced in easy-to-clean colors . . . and in plain, textured or embossed designs. And here's the beauty of Clad from a production standpoint: It can be cut, crimped, drilled and even deep-drawn, without affecting color or design . . . without distorting the material itself . . . and without the need for any special processing equipment or methods.

Truly, Masland Duran Clad merits your most serious consideration right now . . . for, make no mistake about this: *vinyl-to-metal laminates are here to stay and grow.* With production soaring from one million square feet to 18 million in just three years . . . and from 125 to 165 million square feet estimated for 1961 . . . they are obviously lowering finishing costs and increasing design flexibility in a big way.

To safeguard and improve *your* competitive position, you will find it well worthwhile to mail this coupon for more information on Masland Duran Clad . . . and the laminators serving your area.

Industrial Products Division

THE MASLAND DURALEATHER COMPANY, Dept. PE-A, Philadelphia 34, Pa.

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CLAD
vinyl finish

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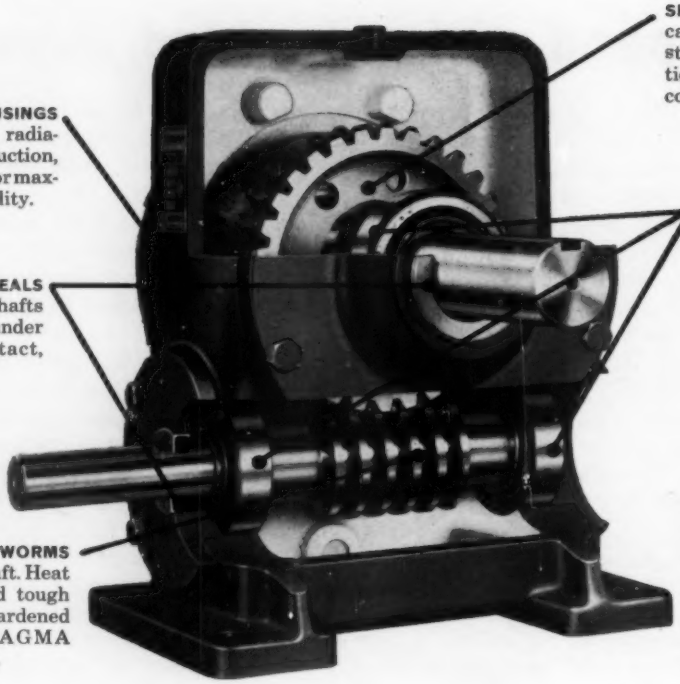
Engineering Data

WINSMITH SPEED REDUCERS

WINSMITH "C" SERIES WORM GEAR SPEED REDUCERS



SPECIAL BRONZE WORM GEARS cast to recommended AGMA standards. Low coefficients of friction and thermal expansion for cooler, more efficient operation.

CAST IRON HOUSINGS designed for high heat radiation. One-piece construction, close-grained gray iron for maximum strength and rigidity.

TAPERED ROLLER BEARINGS for minimum maintenance, long bearing life, permanent shaft alignment. Capacity to handle high radial and thrust loads.

POSITIVE OIL SEALS keep oil in, dirt out. Shafts lapped to micro-finish under seals for uniform contact, longer seal life.

CASE-HARDENED STEEL WORMS cut integral with the shaft. Heat treated for close-grained tough core, carburized and hardened before grinding. Meet AGMA long-wear specifications.

AVAILABLE in single and double reduction models, for intermittent or continuous service. Order from stock with right-angle or parallel shafts, worm on top or bottom, all worm gear or combined worm and helical. All types of special units also available.

- *108 Models*
- *1/100 to 34 H.P.*
- *Ratios 5:1 to 4460:1*
- *Max. Output Torque 142 to 34,767 in. lbs.*

Winsmith "C" Series Reducers are compact units which offer a wide range of horsepower and torque output in minimum space. Their design and construction provides high shock load resistance; maximum thermal capacity without induced cooling; greater overhung load capacity; all moving parts totally enclosed in a dirt-proof housing and lubricated from a central oil bath; and complete interchangeability of major components. These features add up to smooth, trouble-free performance—an extremely low rate of wear—high mechanical efficiency—and greater overall economy per horsepower dollar.

For complete information on Winsmith Speed Reducers, write today or call your nearest Winsmith Representative. You'll find one in every major industrial area, listed in the Yellow Pages. They are technically trained experts who are always ready to help you with any speed reducer problem. For both standard and special power transmission applications, you'll find it pays to standardize on Winsmith.

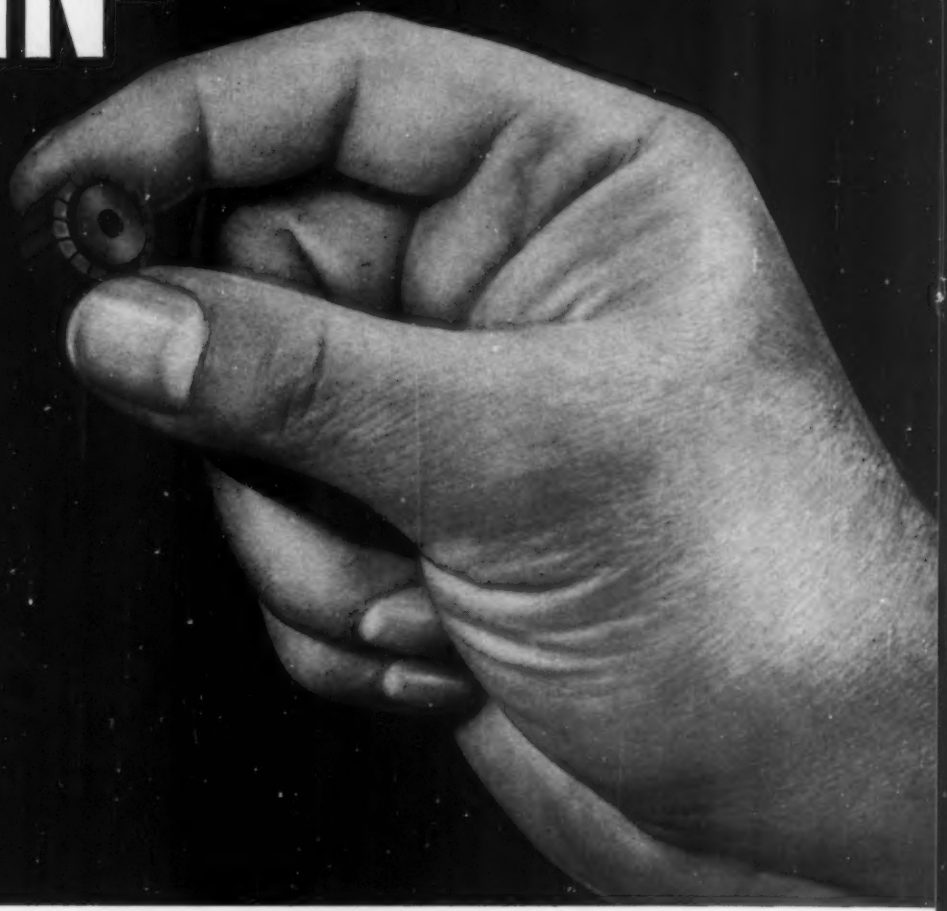
WINSMITH, INC.

208 Eaton Street, Springville, (Erie County), New York

MEMBER OF AGMA

• • • Winsmith Speed Reducers are made by American craftsmen to meet American design and production standards.

AGAIN-



Revere helps "fit the metal to the job"

AND A COMMUTATOR MANUFACTURER SAVES ON BOTH MATERIAL COSTS AND OVERALL COSTS WHILE PRODUCING A SUPERIOR PRODUCT

The hub of the small commutator you see above originally was made of a ferrous metal. Certain problems cropped up due to the fact that the rod from which the hubs were fabricated, not only had to be drilled, but it also had to be able to withstand a flanging operation. The engineering department of Dayton Precision Manufacturing Company called in one of Revere's Technical Advisors for consultation.

After a thorough study of the problem Revere Brass Rod of a certain alloy was recommended and samples were furnished. The machinability of the rod was found to be outstanding, being readily and speedily drilled. Also it withstood the flanging operation . . . a set of manufacturing conditions where only brass, the right kind of brass, outshines all other metals and alloys.

Final score: The low first cost of the brass rod, plus its superior machinability, resulted in a more satisfactory product without the penalty of higher costs. A further advantage to the manufacturer was the added sales appeal of the brass hub.

And there you have another example of how Revere in collaboration with the manufacturer helped, "fit the metal to the job," which resulted in a better part at the least possible cost. Why don't you take advantage of this kind of service?

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

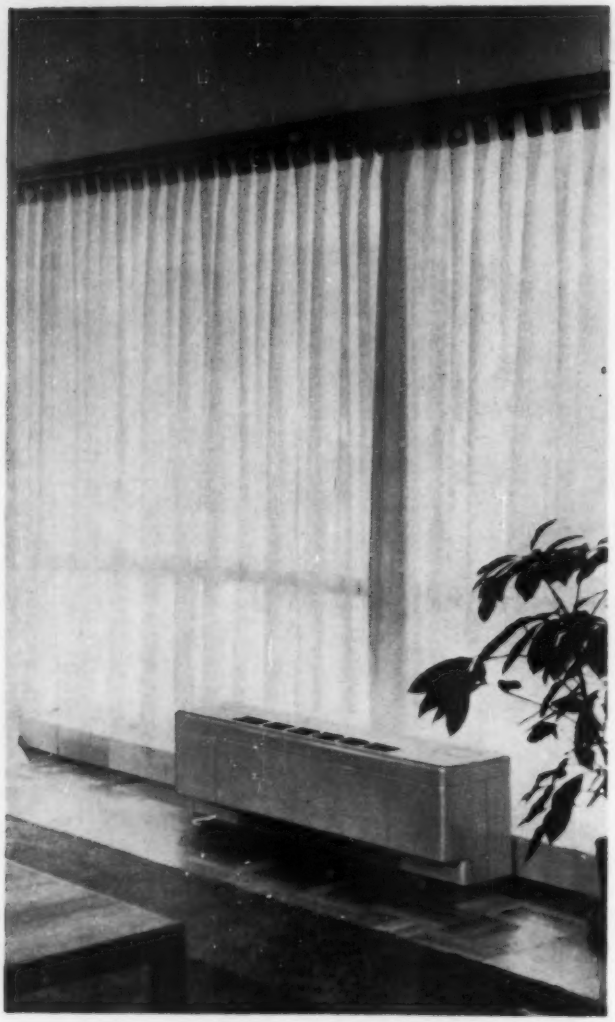
230 Park Ave., New York 17, N. Y.

Sales Offices in Principal Cities. Mills: Rome, N. Y.; Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles, Riverside and Santa Ana, Calif.; New Bedford and Plymouth, Mass.; Brooklyn, N.Y.; Newport, Ark.; Ft. Calhoun, Neb.

Distributors Everywhere.

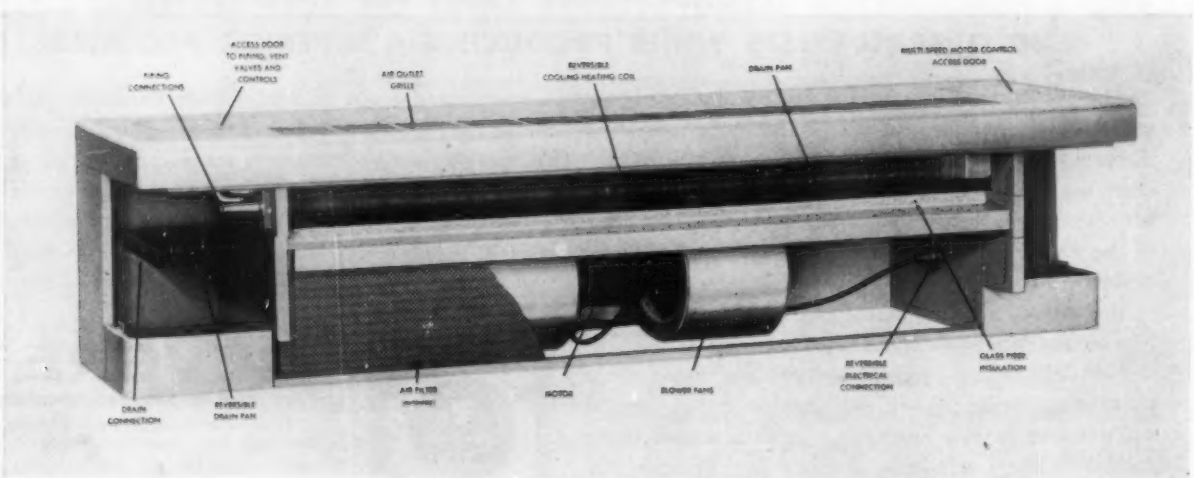
CIRCLE 23 ON READER SERVICE CARD

TRENDS IN INDUSTRIAL DESIGN

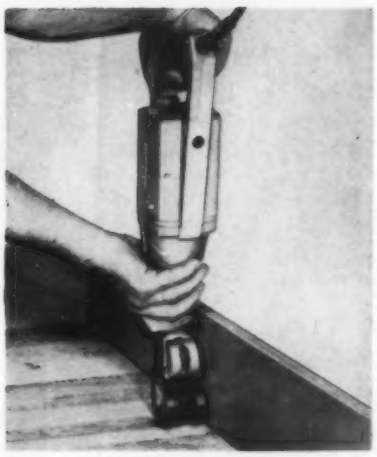


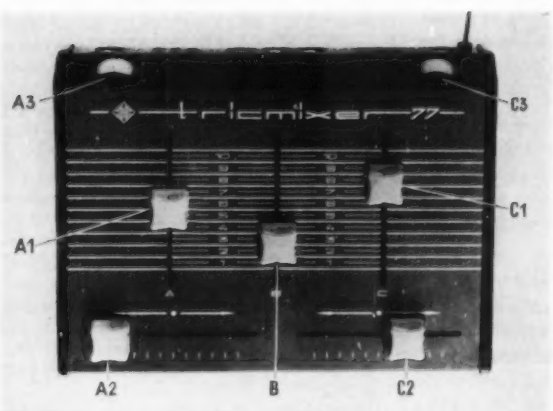
FLOOR-TO-CEILING GLASS AREAS present special problems for heating- and cooling-equipment designers. To place standard, 25-in.-high fan-coil units in corners or overhead would be unsightly, and not nearly as efficient as putting such heating or cooling sources directly below the glass areas themselves, where heating and cooling loads are concentrated. Units low enough to be located at center of the window bases could blanket window exposure directly, offsetting heat gain or loss and making possible much more exact temperature control.

The architects for an apartment building community in Chicago—Skidmore, Owings and Merrill—discussed this problem with the engineers of Modine Mfg Co and with J. O. Reinecke, Chicago industrial design consultant. A free-standing fan-coil unit only 14½ in. high was developed, with blowers and motor packaged horizontally so that conditioned air is distributed over glass area. Small-dia pipes deliver heated or chilled water from a central source, eliminating the expensive, bulky air ducting that characterizes most large-volume heating-cooling systems. The unit, now available, is made in a series of models with 14,300 to 44,900 btu/hr ratings.

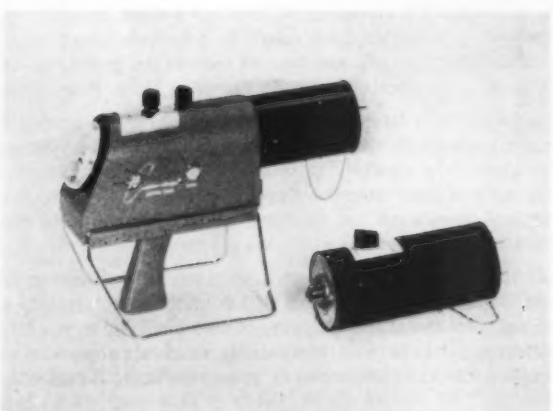


RECIPROCATING SAW for cutting wood, metal and composition materials has ½-hp electric motor. Tapered front section helps get into confined areas, and its shape provides simple grip for operator's left hand. However, fairing top of handle frame into motor body would have made for even more compactness and maneuverability. Made by Millers Falls Co, Greenfield, Mass.

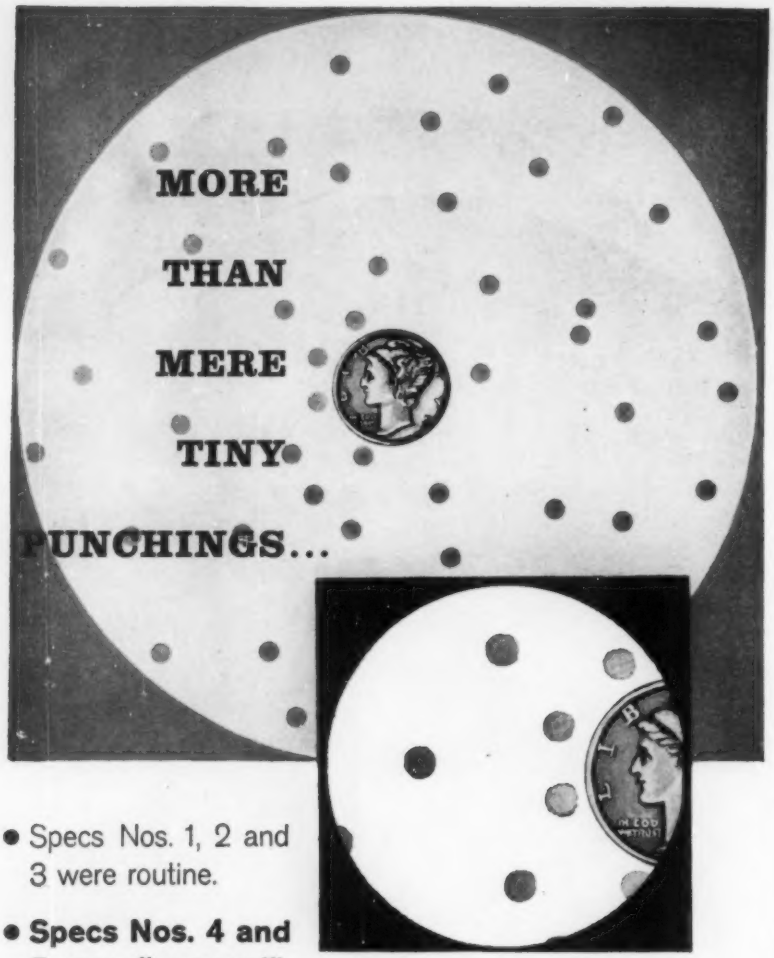




STEREO AND HIGH-FIDELITY "bugs" are notoriously proud of their equipment's impressively complicated control panel, but even they might have trouble deciphering this mixer's knobs, dials and nearly unreadable graphics. Unit permits simultaneous mixing of stereo microphone channel with two additional monaural sound sources, such as pickup and tape recorder. Volume and direction from which these secondary sources appear may be varied during playback. Made by Telefunken Gmbh, West Germany.



GUN-TYPE SURVEY METER measures beta, gamma and X-rays of low and medium intensity. By changing plug-in ion chambers, either rate-of-dose or accumulated-dose measurements may be obtained. Over-all shape and arrangement of components, meter and control elements are good; but even when hand-held instruments such as this are treated carefully they still need rugged, compact construction—and that surface-mounted meter, that speckle-finished case and those wire legs don't look too capable of "taking it." Manufactured by Nuclear-Chicago Corp, Des Plaines, Ill.



- Specs Nos. 1, 2 and 3 were routine.
- **Specs Nos. 4 and 5 were "unusual".**

What you are looking at are specimen holders for an electronic microscope. They're so small that it takes about 40 to cover a dime. Specifications as to kind of metal, diameter of wire and mesh might be considered routine. It's what we did with the cloth before punching and how we treated the punchings that are important. Spec No. 4 especially tested our manufacturing skills. No. 5 called for special cleaning.

We started with NEWARK Stainless Steel 200 x 200 Mesh Cloth woven with 0.0021 inch diameter wire. Cloth thickness was 0.0042 inches. Then we rolled or calendered the cloth very carefully to 0.0025 inch thickness. After clean-cut punching, we cleaned and passivated the pieces in dilute nitric acid, imparting to them an almost surgical cleanliness...a cleanliness which was retained through the packing. The discs had to be kept free of foreign matter.

As pointed out above, the cloth itself is not uncommon but the rolling and treatment were somewhat unusual. The skill in handling and quality of work typified by this job suggests the skill and quality of work available to you for any "wire cloth" insert project you have in mind. Incidentally, much of our work is in preparing "punchings" in all diameters in single pieces, in segments, or in sectors.

NEWARK for ACCURACY

Newark Wire Cloth COMPANY

351 Verona Avenue • Newark 4, New Jersey

READER TO EDITOR

He Says Phooey to PhD's

To the Editor:

I noted with disdain the innocuous opinions of the various contributors to your "Points of View" in the Nov 21 issue ("Are Advanced Degrees Essential to R & D Work?"). Innocuous only in the sense that they cannot add much more to the great amount of harm already effected by the ultimate consequence of such opinions held and carried out in practice.

It would be interesting to pose this same question to such men as Kettering, Franklin, Edison, Faraday and many others, all educated men of high intellectual achievements but none of whom ever attained the "discipline" represented by the present-day doctorate degree. There is no doubt about it that all thinking men of all ages in history will exhort those who are capable, to expand their knowledge and try to attain the highest proficiency in their chosen field, but who has given this smug, conceited clique the authority to say, in effect, "Unless you receive your official license from one of our institutions, working under the aegis of such institutions and one of our fellow turnkeys, you shall forever more be classed under the labels of uneducated, incapable, and inconsequential!"?

The undergraduate engineering course at *any* university is not sufficient to make the bachelor a fully competent engineer or scientist. In fact, most if not all university catalogs claim only that he (the bachelor) is qualified to "enter the field," and nothing more.

We then behold some magic process by which an admittedly incompetent bachelor is, in the short space of three years, endowed with the knowledge and skills of the ages. He, the new "doctor," now has a "discipline" which makes him an educated intellectual and this "discipline" was demonstrated in an original work explained in detail (more or less) in a thesis of which about 99% or more is pure, unadulterated gobbledygook. We then observe the fruition of this ridiculous process wherein a full competent engineer who has spent 10, 15, 20 years, or even longer, in zealous pursuit of his chosen field, every bit as widely and as deeply read, having written many more *original* reports, performed many more *original* investigations, designed original equipment, granted many patents, etc., being bluntly told in an interview that the company desires the services of a more competent "three-year wonder."

Mr Zarem is totally wrong in stating that the day of the lone inventor or inventors is gone. Problems which he speaks of as requiring group skills are just what he calls them, development or improvement of hardware, and he is justified in entrusting the pursuit of such routine problems to the intelligence and skills of the present-day crop of PhD's.

Mr Ference speaks of "fundamental research" but the greatest part of today's

continued on page 30

IMPACT!

This is a "warhead". It's the front end of a carrier which darts through a pneumatic tube system at speeds up to 20 mph, and is subject to frequent shocks and impact. There's a story behind the choice of LEXAN® polycarbonate resin for this new design . . .

Formerly, destinations were set by contacts along the entire body of the carrier. Engineers of Airmatic Systems Corporation, Saddle Brook, New Jersey, reasoned that if all the control elements could be fitted into a small impact- and wear-resistant head, the rest of the carrier could be designed for easy maintenance and quick replacement. Many plastics had the required dielectric strength, but none could measure up to LEXAN resin's combination of good electrical properties, excellent dimensional stability and extremely high impact strength. LEXAN resin actually withstands over 12 foot-pounds per inch of notch — an impact strength attained by no other plastic!

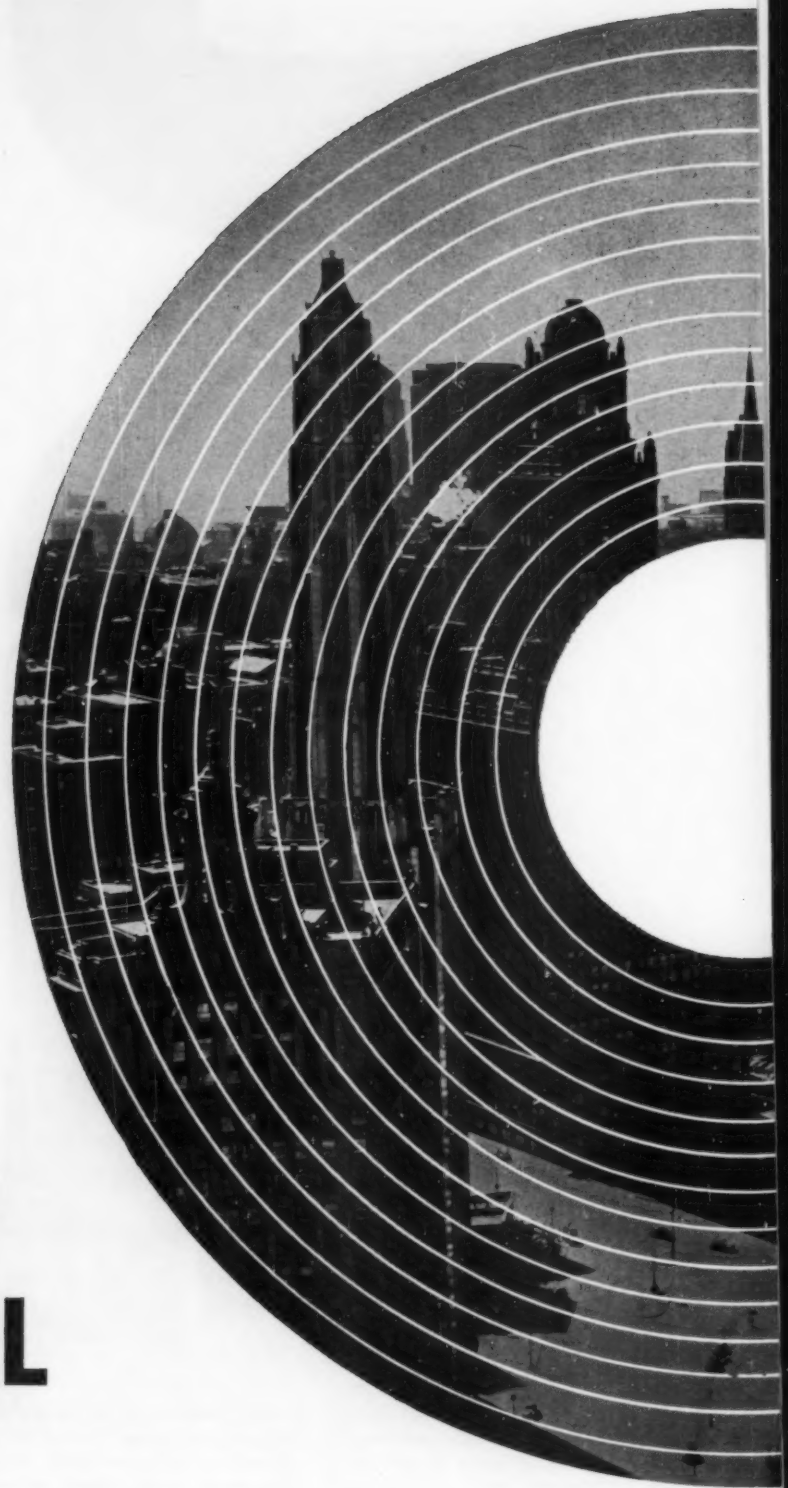
The new warhead is injection-molded of black LEXAN resin by Berkeley Engineering & Manufacturing Co., Berkeley Heights, N. J. Now when wear and tear take their toll, the transparent carrier body is easily replaced, since it has no control elements. Also, body length can be varied to suit customer needs, and carrier weight is reduced. Printed circuits and compactly arranged brushes and control plates are used. The new design is more attractive, more practical, less costly. And—LEXAN resin warheads have proved in field tests to last longer than the old control units.

G.E. LEXAN polycarbonate resin has raised the quality of many designs to new levels. It has been reduced in price approximately 40% over the past year! Can this tough, new thermoplastic help you? Send for design literature.

LEXAN®
Polycarbonate Resin

GENERAL ELECTRIC

Chemical Materials Dept., Section PE-11, Pittsfield, Mass.



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MORE
GALVANIZED
STEEL
FOR
MID-AMERICA
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MIDWEST STEEL

For one of the greatest steel-consuming areas of the country, galvanized steel will now be in greater supply. The source is close, the service is fast, and the quality is second to none. Because

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PRODUCT APPLICATION

HANSEN SYNCHRON TIMING MOTORS

synchronous power source for

ELAPSED TIME INDICATORS

Hansen SYNCHRON motors being assembled into Hobbs engine hour meters

JOHN W. HOBBS CORPORATION, a leading manufacturer of running time meters, uses Hansen SYNCHRON Timing Motors to provide the power for efficient, dependable, long-lasting operation of such devices. The elapsed time indicators measure running time on such typical installations as machine tools, air compressors, motor generator sets, and other equipment run by alternating current.

HANSEN SYNCHRON TIMING MOTORS exceeded the requirements set for the synchronous motor and integral gear train providing the accuracy of time so vital to the operation of Hobbs instruments — including accurate performance over a wide range of ambient temperatures to meet certain military requirements. Hansen SYNCHRON motors are furnished to Hobbs to meet voltage specifications that vary from 120 - 240 - 480 volts, at 25 - 50 and 60 cycles.

The application described demonstrates another way in which Hansen SYNCHRON motors serve as an integral part in product operation. You may be able to profit from such dependable performance applied to your timing application, now being planned or in production. SEND TODAY for informative folder detailing specifications and technical data on all Hansen SYNCHRON Timing Motors and Clock Movements.

HANSEN MANUFACTURING COMPANY, INC.
PRINCETON, INDIANA

HANSEN REPRESENTATIVES:

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5150 W. Madison, Chicago, Illinois

H. C. JOHNSON AGENCIES, INC.
Rochester, N. Y. — Buffalo, N. Y. — Syracuse, N. Y.
Binghamton, N. Y. — Schenectady, N. Y.

ELECTRIC MOTOR ENGINEERING, INC.
Los Angeles, Calif. — (OLive 1-3220)
Oakland, California

WINSLOW ELECTRIC CO.
New York, N.Y. — Essex, Conn. (SOuth 7-8229)
Philadelphia, Penn. — Cleveland, Ohio

Sweet's Product Design File

30 CIRCLE 30 ON READER SERVICE CARD

so-called fundamental research is nothing more than technical dog work, requiring the skills of highly trained technicians, which the great majority of PhD's are—that and nothing more. Ference further states that no amount of on-the-job or after-hours' training (including study, I suppose) can replace the value of intensive disciplinary pursuits, etc., etc.). These spokesmen for the "pro" are attempting to give the impression that every bit of knowledge that is passed over is retained.

In their endeavor to glut the market with these synthetic intellectuals (the great majority of whom never heard a Beethoven symphony, read a Shakespearean play—except under duress—Aristotle's *Physics*, or Descartes' *Discourse on Method*), we find universities approaching the ridiculous in mass institutional reasoning. We find one of our large midwestern universities blatantly boasting in the daily press that it conferred the degree on a 23-year-old. Here we have the spectacle of a so-called institution of higher learning boasting of a condition of which they should be ashamed.

—J URBAN DALY
Worthington, Ohio

COMING EVENTS

JANUARY

29-Feb. 3 . . . . American Institute of Electrical Engineers, Winter General Conference, NYC

FEBRUARY

1-4 . . . . Institute of Radio Engineers, Winter Convention on Military Electronics, Biltmore Hotel, Los Angeles

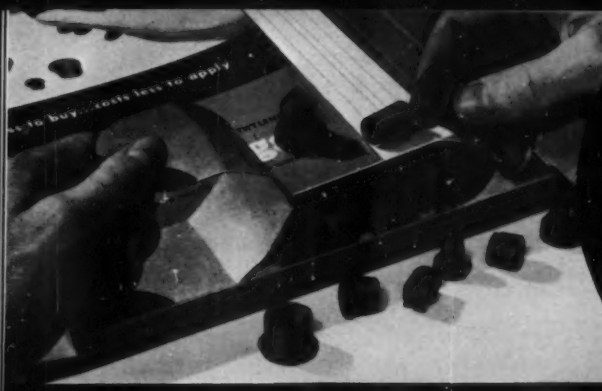
7-9 . . . . Society of the Plastics Industry, 16th Annual Technical & Management Conference, Edgewater Beach Hotel, Chicago

14-16 . . . . Society for Nondestructive Testing & Southwest Research Institute, 2nd Annual Symposium on Nondestructive Testing of Aircraft & Missile Components, Gunter Hotel, San Antonio, Texas

15-16 . . . . Institute of Radio Engineers, American Institute of Electrical Engineers, 8th Annual International Solid-State Circuits Conference, Univ of Pennsylvania & Sheraton Hotel, Philadelphia

26-March 2 . . . . American Institute of Mining, Metallurgical & Petroleum Engineers, Chase Park Plaza & Ambassador Hotels, St. Louis

For a current listing of addresses of societies and associations send 25¢ to PRODUCT ENGINEERING Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure, R 32.



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With all matching parts and mounts machined to close tolerances, O-M Air and Hydraulic Cylinders eliminate misalignment friction, unnecessary wear on rod, bearings packings, also reduce maintenance, when operated singly or in sequence under automatic cycling. The length and direction of piston rod travel is accurately controlled whether the job calls for moving a machine member, holding a tool, positioning, clamping, releasing a work piece, activating an indexing table or other applications. In addition, precise cushioning against piston shock on thrust and return strokes makes for smoother, dependable operation.

O-M Cylinders are available in a complete range of sizes (1½" to 8" bores) with standard or heavy-duty rods. Complete line of interchangeable parts and mounts. Immediate delivery on most sizes.

If you are designing air or hydraulic cylinders into original equipment for precision control of linear motion, coupon below will bring our latest bulletins showing construction and dimensional details, engineering drawings, capacity chart and mounting data. For your copies, **MAIL COUPON TODAY.**

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Bulletin 107—Automation (Heavy Duty) Air Cylinder for 200 psi operation.

Bulletin 108—Automation (Heavy Duty) Hydraulic Cylinder—for 1000 psi operation.

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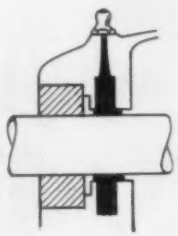
WHY DON'T THEY R&D..?

. . . an electric blanket that will heat in winter, cool in summer. The new semiconductors have already been applied in thermoelectric cooling applications of this kind. It therefore seems possible to manufacture a blanket with semiconductor filaments woven between layers of cloth (the best insulation at the top) to do the job. Other applications include cooling of fire-fighters', steel-workers', pilots' and astronauts' suits. Going one step further, it might be practical to use this semiconductor material as a head band or wristwatch-size cooler to be strapped over the arteries of hands or neck. Powered by line voltage or battery, it could operate as a personal body-temperature conditioner.

. . . a clock radio "sleep switch" which decreases the volume gradually rather than suddenly (and with a click) at the end of a set time. Often the sudden silence is more disturbing than a noise would be. A motor-driven rheostat or thermally actuated attenuator might be used to cut the volume slowly and prevent waking the sleeper.

. . . a chemically expandable packing gland material for rotating seals. Premixed with activator, the chemiseal material might be pressure pumped into new or leaky seals through grease-gun type fittings. In time the material would expand and polymerize to form a good pressure seal. The material might contain graphite or moly disulfide lubricant embedded in the mix.



. . . parking lights for cars that can be left on for long periods without running down the car battery. Most people hesitate to leave parking lights on overnight, even when car is in a hazardous location, because of high battery drain. A transistorized neon flasher, drawing only a tiny fraction of the current of present parking lights, might do the job. This would be similar to the neon road construction warning lamps now in use which operate from 150-v batteries for periods of many months—but a transistor circuit would be required (like those in electronic flashers for photography) to step up the 12-v battery supply.

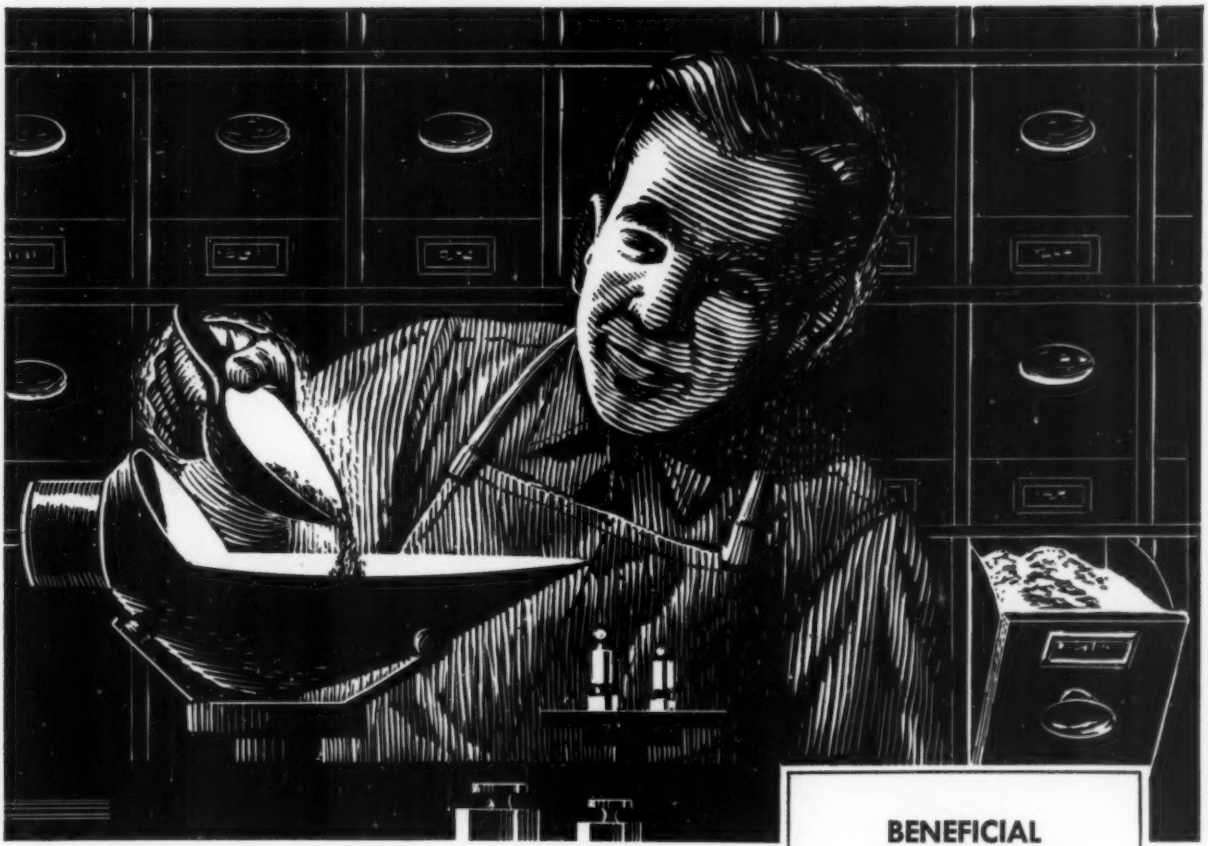
. . . powered fishing reels. The tiny battery-operated motors now available might be suitable. Casting would be as usual but retrieval could be accomplished at the touch of a button (with switchable voltage to control wind-up speed). Regular wind-up crank should be supplied, of course, for playing fish or when batteries die in midstream.

—R Marie

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.

Kopp Glass

can create glass parts to meet your exact needs



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Kopp engineers have the experience, facilities and "know-how" to analyze your requirements *precisely*. They develop the "batch formula," properly proportioning and mixing carefully-measured ingredients.

This mix is melted under accurately-controlled temperatures and the molten glass is pressed to exact dimensions in Kopp-engineered molds. Subsequent cooling, annealing, grinding and finishing — under strict quality control — provide the components to meet your design requirements *exactly*.

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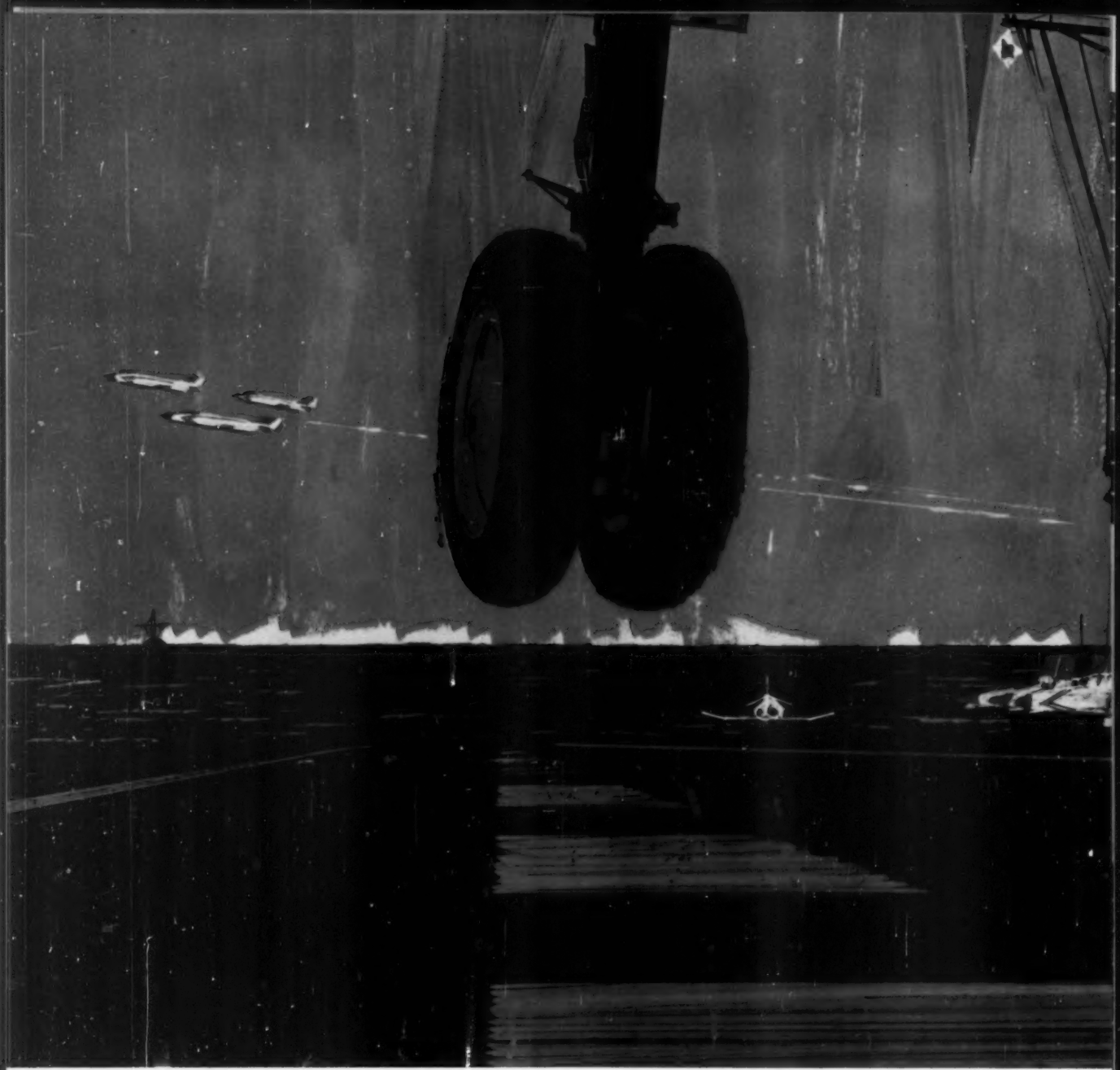

NS SPECIAL WIRE WITHSTANDS 1000°F

Landing hot jets like the McDonnell Phantom II at high speeds, means brakes and brake components must be able to withstand extreme temperatures without failure.

A leading manufacturer of brakes for jet aircraft came to National-Standard for help in finding a spring wire that would have high stress-temperature stability up to 1000°F. National-Standard engineers recommended an austenitic superalloy material, NS-A286, recently developed for spring wire applications by National-Standard. Tests showed that NS-A286 met requirements better than any other available alloy, yet cost only half as much as the next best alloy.

SUPERALLOY PASSES TEST—When brakes on the Phantom II are released, the NS-A286 return springs under the brake discs must separate the stationary stator discs from the moving rotor discs. The brake discs build up heat to 1400°F, which is quickly absorbed by the return springs, raising spring temperatures to as much as 1000°F. NS-A286 is a precipitation hardening alloy exhibiting as little as half the relaxation loss at 1000°F as comparable alloys show at 850°F. NS-A286 springs must retain their strength at this heat to separate the brake discs and guard against brake drag during landings.

To test NS-A286, engineers simulated stress-temperature characteristics of three landing conditions.

TO BRAKE JETS

Heat builds up in the brakes in 30 seconds and remains for as long as 20 minutes. The springs must work in the heat against a high back pressure maintained in the aircraft hydraulic system. Springs must be operational for at least 45 normal landings, 5 high-speed, gross weight landings, and one aborted take-off stop, corresponding to stopping the plane just before it becomes airborne. Under all test conditions, NS-A286 met every rigid requirement.

EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring high-quality wire, to meet special or unique applications, is available to you from National-Standard. Write for additional information to National-Standard Company, Niles, Michigan.

NS-A286 SUPERALLOY WIRE, produced by National-Standard, meets critical stress-temperature demands for coaxial return springs in brakes of F4H-1 Phantom II.

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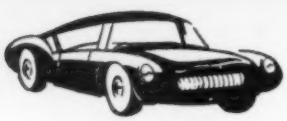

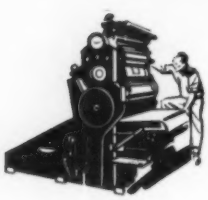

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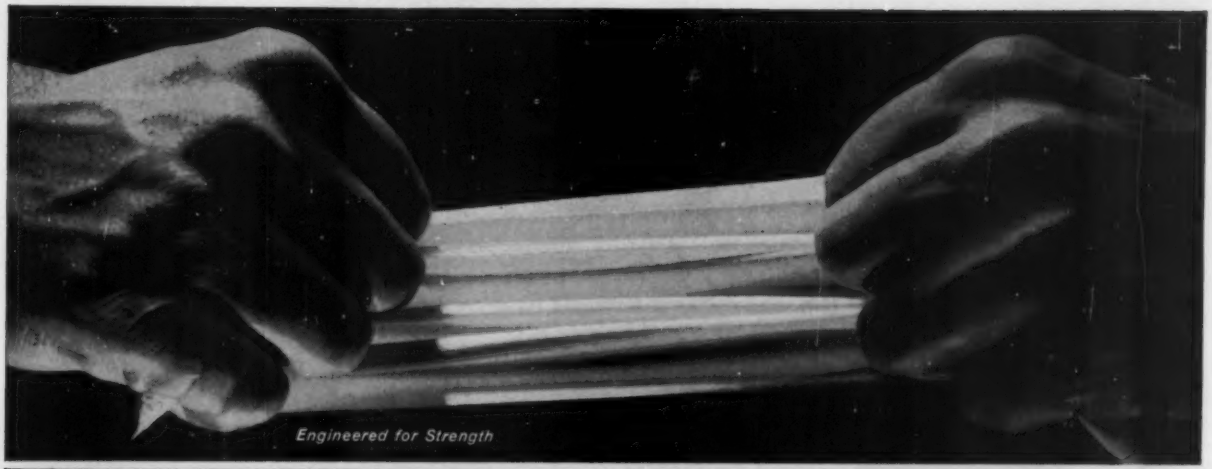
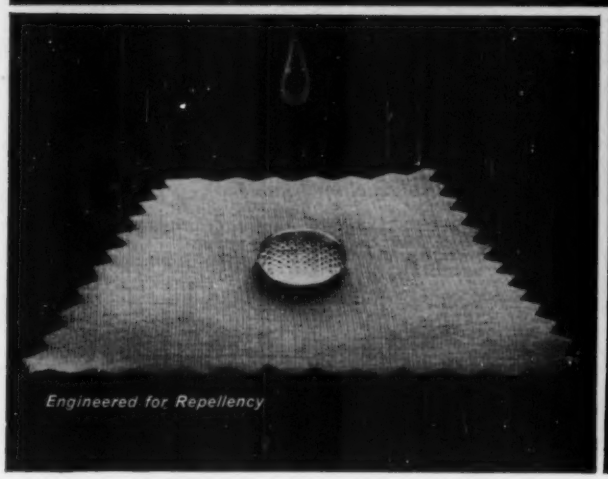
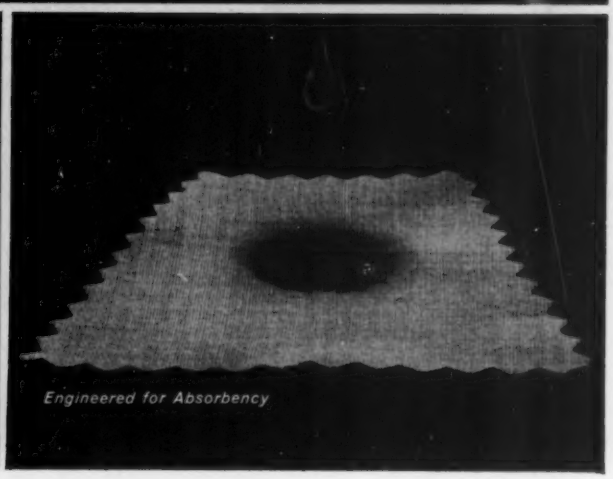
An example of Avisco Rayons in Industry







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The big news in industry today is the increasing use of Avisco rayon fibers. Versatility is the reason. Avisco rayon can be custom engineered to meet your end-use requirements.

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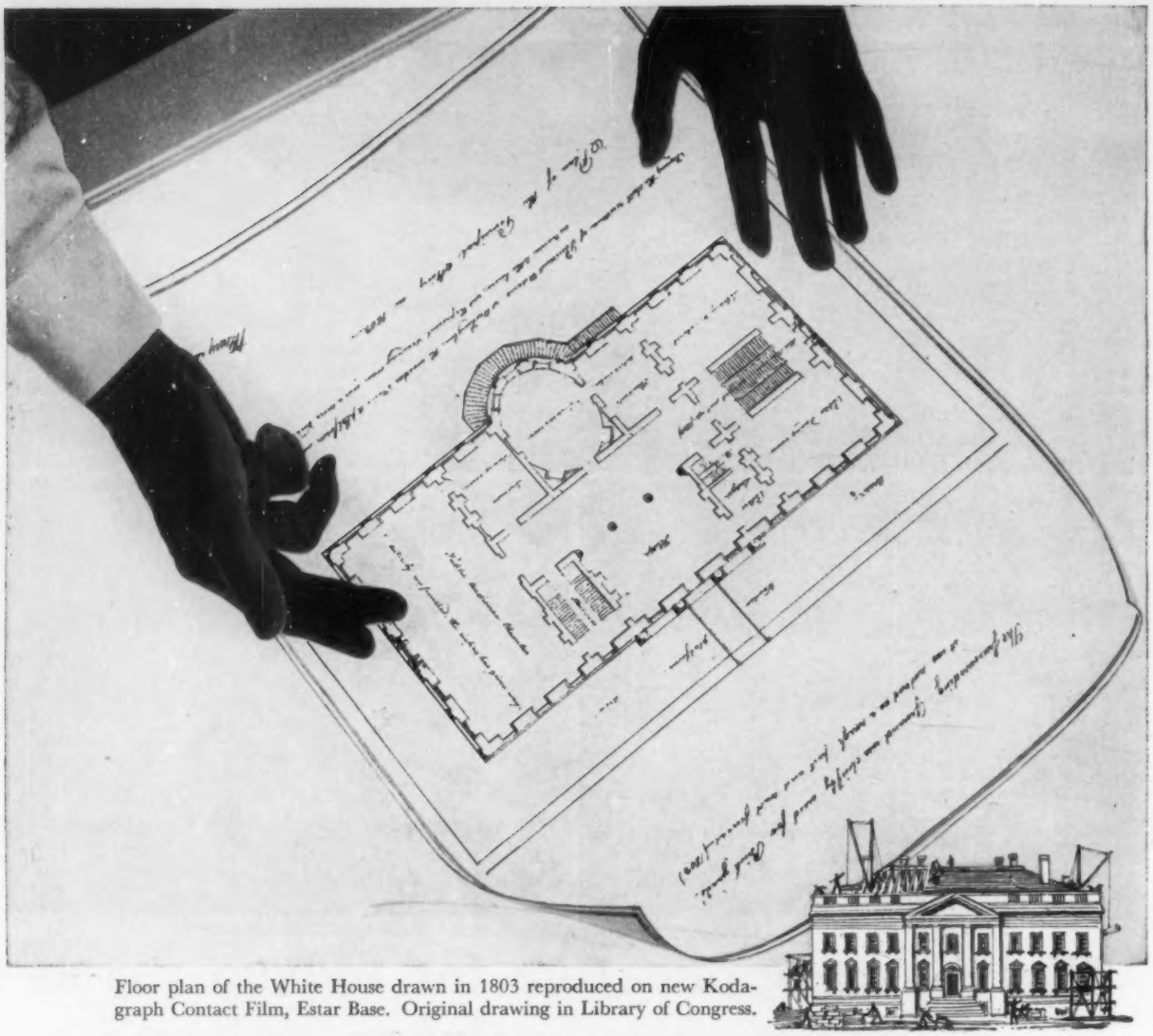

Floor plan of the White House drawn in 1803 reproduced on new Kodagraph Contact Film, Estar Base. Original drawing in Library of Congress.

New way to restore old drawings!

New Kodagraph Contact Film, Estar Base, transforms old, soiled, or weak-lined drawings into top-quality intermediates which will stand up under punishment in print-making machines and on drafting boards.

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See this new Kodagraph Film—and the others in the new *Estar Base line:* Kodagraph AutopositiveFilm; KodagraphProjectionFilm. *All combine* reliable Kodak emulsions on the new Estar Base—highly translucent, durable, and dimensionally stable, with excellent matte surface on both sides for easy drafting. Available in standard drawing sheet sizes and in rolls up to 52 inches wide. Call your local Kodagraph Dealer, or write Eastman Kodak Company, Graphic Reproduction Division, Rochester 4, N. Y.

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PRODUCT ENGINEERING HORIZONS

January 23, 1961

But is it progress?

Last week I talked of society's resistance to new developments, epitomized by congressional resistance to the dial telephone and to the stopwatch. There is, of course, another side to the coin—the endless number of advances which technology has made possible that aren't really advances. Following Parkinson's Law, they just require *more* manpower, *more* time and *more* specialized training to make work. And they deliver *less* reliability, *less* maintainability, *less* serviceability.

I recall seeing a new, totally mechanized unit for cleaning out spaces between commutator segments. It was quite an impressive machine, with a number of ingenious motions. Up to that point, it had cost $40,000. It had only one flaw—it didn't do the job any faster than the old method.

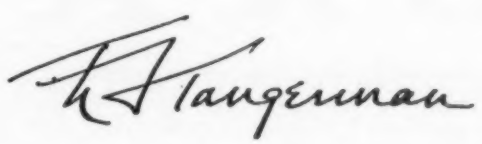
You will recall the more recent case of the mechanized marvels on TV that computed the predictions during the election. They were very impressive to watch—but human pollsters out-predicted them, just as the abacus in the hands of a skilled operator can beat a calculator. There are still some operations that a human brain can do faster than any electronic wizardry. One of them is thinking.

Some of these unworthy thoughts intrude when we see such marvels of modern technology as electric can openers, electric pencil sharpeners, and electric shoe buffers. Our scepticism is likewise awakened by the ball-point pen that fails (except under water), the TV dinner cooked by pushbutton, "radar-broiled" hot dogs, the automobile record player and shaver—even the pocket cigaret lighter that must be backed up by a packet of matches.

The point about mechanized wizardry is that it depends upon two other fairly modern ideas—preventive maintenance and thoughtful operation. Neither of these is or will be provided by John Q Public, so the sophisticated device is wasted on the average consumer. Further, mechanical sophistication is like canine or equine breeding—you can progress to something so refined that it's impossible to live with.

A new book, "The Crisis We Face," by George Steele and Paul Kircher (McGraw-Hill—$4.95) suggests this possibility in connection with our super-sophisticated missile-guidance systems as compared with the reported Russian control by tape recorder. Sometimes, the engineer, like the architect, goes all out to make his brain-child as elaborate as possible, rather than as simple and reliable as he can make it—just to prove his originality and skill. Then somebody must remember the pocketbook and call a practical halt.

The moral seems to be that it isn't what you can design that counts, it's what you can sell. The moral fits all these situations, whether the pocketbook is worn by you, your company, or your government.



MECHANICAL SEALS
in Design Engineering

Where leak-proof operation is an absolute must, Garlock PK MECHANIPAK Seals are the ideal solution.

Easy to install and maintain. The Garlock PK MECHANIPAK is self-contained—no parts to "put together." Rotating portion simply slides onto shaft; stationary portion positions quickly into counterbore of gland. Once the Garlock PK MECHANIPAK is installed, further adjustment is unnecessary. No parts of the seal move on the shaft or sleeve, eliminating wear on shaft . . . spring in seal maintains contact between sealing faces.

For rotating shafts of equipment such as centrifugal pumps, automatic washing machines, commercial dishwashers, gear boxes, and speed reducers, Garlock PK MECHANIPAK Seals offer these operating characteristics:

PRESSURES—up to 150 p.s.i. with Buna-N or Viton† bellows

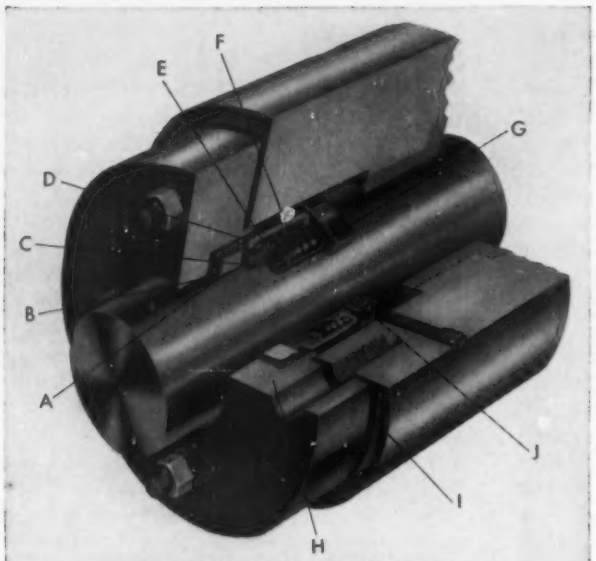
TEMPERATURES—up to 212°F with Buna-N bellows; above 212°F with fluid at faces and Viton bellows

SHAFT SPEEDS—up to 2000 f.p.m.; higher speeds possible depending on other operating conditions

LIQUIDS—water, oils, alcohol, mild acids and solvents

SIZES—for shafts 3/8" to 3" diameter

DRIVE—mechanical; install against shaft shoulder, sleeve, pump impeller, snap ring, stop collar or similar device.



Garlock PK MECHANIPAK* Seal

A Stationary Seat—lapped face
B Vibration Ring
C Seal Ring—lapped face
D Case or Shell
E Bellows
F Spring
G Washer
H Gland
I Gasket
J Stop Collar

To meet various operating conditions, PK MECHANIPAK seals are made in several different designs. For the complete story, get in touch with the Garlock representative in your area. Call him at the nearest of the 26 sales offices of Garlock throughout the U.S. and Canada. Or write for Catalog AD-150. Garlock Inc., Palmyra, N. Y.

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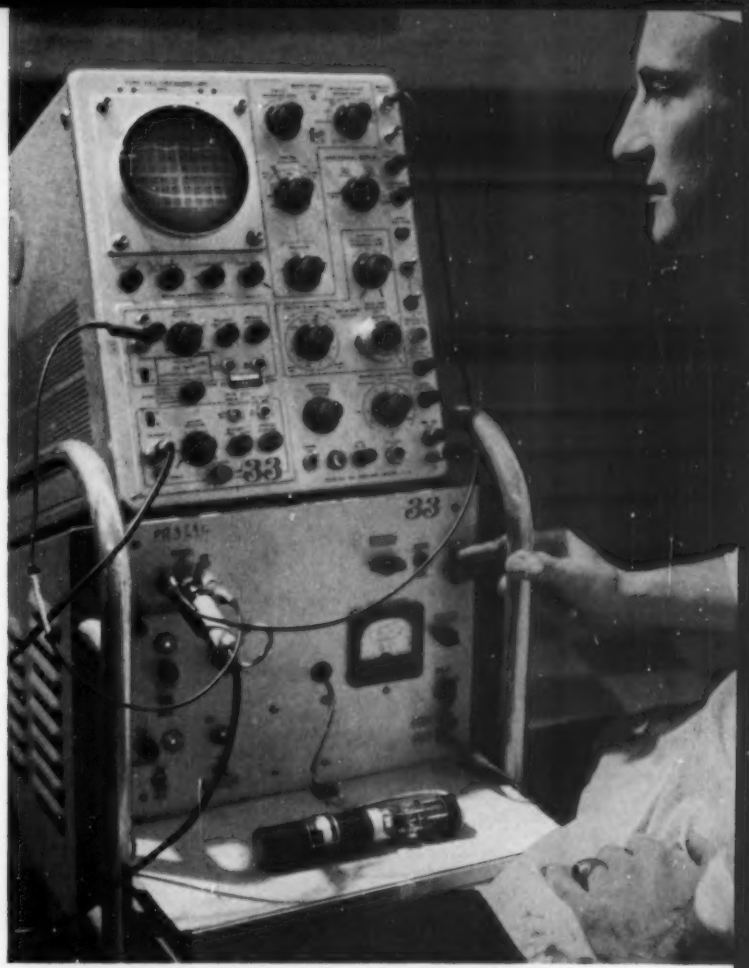
PRODUCT ENGINEERING

Realistic Ways to . . .

SPEED RESPONSE OF DC CLUTCHES AND BRAKES

SAL IATESTA, *project engineering group leader*
Kearfott Div
General Precision Inc



TEST SETUP—The author measures response time of a braked servo on oscilloscope.

Here's an analysis of response time in three logical steps—1. What is response time? 2. What speeds are practical? 3. How will standard units give you extra speed?

Before specifying an electromagnetic clutch or brake, take a second look at one of the major parameters–response time. Although it influences cost and precision, response time often is not fully understood, and this leads to expensive overdesign. For example, when pushing practical limits of clutch or brake, a difference of four or five milliseconds can double or triple cost. Same drawback occurs when overdesigning any electromechanical device.

It's not surprising that users of electromagnetic clutches or brakes are confused: the various manufacturers themselves can't agree on a standard definition. Some say response time is the time required for the two magnetic surfaces to meet (indicated by a click at the instant of contact, or by leading edges of pips shown on an oscilloscope). For the purposes of this article, because it seems more practical from the users' point of view, we will define response time as the time required from energization or deenergization to couple the two shafts together at rated torque and speed, or for a brake, time from signal to complete stop. For example, in photo above, taken in a "clean room" at Kearfott, trace on oscilloscope shows response time of just under 2 millisec for an F 1700 braked servo made for special applications.

HOW TO REDUCE RESPONSE TIME

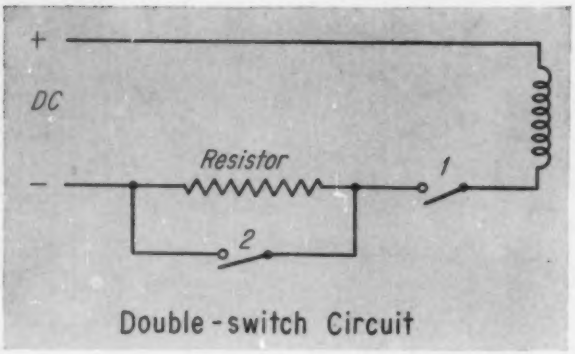
A practical limit on response time is about 10 millisec. Many off-the-shelf units are available from numerous suppliers at this speed or slower. It is when you insist on faster speed of response that cost starts to mount. Speeds under 10 millisec often call for special, custom-built units or special power supplies. A typical military model with a response time of 10 millisec may cost $75. For a speed of 5 millisec, cost may jump to $150 or $200–and climb much higher as you approach today's limit of about 2 milliseconds.

If your application requires a speed of response under 10 millisec, re-examine the other parameters with these questions in mind:

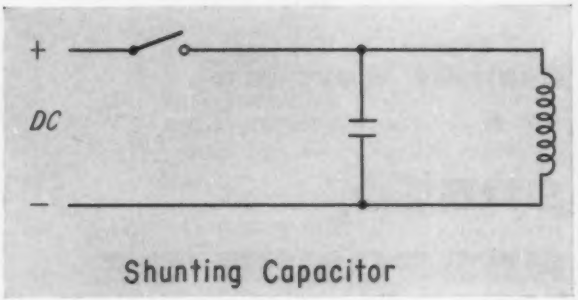
Can you reduce load torque, inertia or rotational speed? Lowering any or all three will greatly reduce response time. The clutch will react quicker–and as a bonus, operating life will increase because of less wear. Or a smaller clutch can be used, resulting in a saving in power.

Can you substitute a larger clutch? If the larger physical size can be accommodated and sufficient extra power is available, the increased magnetic attraction and torque

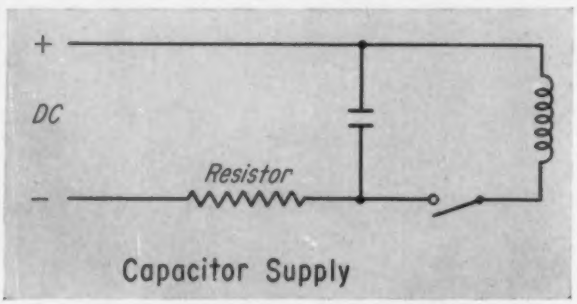
REPRINTED—Circle P79, inside back cover



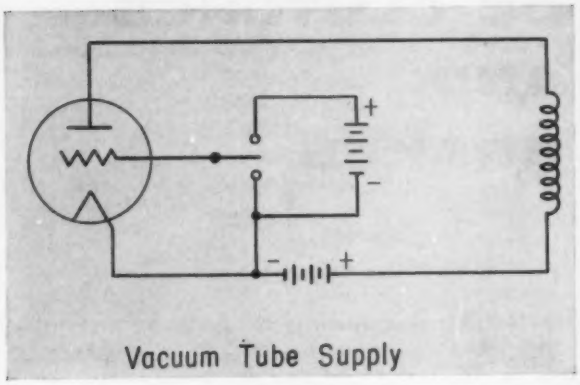
Double-switch Circuit



Shunting Capacitor



Capacitor Supply



Vacuum Tube Supply

capacity will bring the load up to speed faster because, in effect, this reduces load torque relative to the clutch.

Can clutch design be tailored to the application? For example, if fast response is required only in attraction and not in release, you can use a weak spring that barely uncouples the clutch. A normal spring with a higher opposing force will resist coupling and thus slow it down, but it will uncouple faster.

Quick-make circuits

External circuits can reduce response time. Either a short impulse of high voltage, or excitation of the clutch from a constant-current source such as a vacuum tube, will accelerate buildup time for the magnetic field. But external circuitry may require a much higher voltage than is readily available.

Double-switch circuit—when switch *1* is closed to actuate the unit, switch 2 also closes, bypassing the resistance and allowing a high-voltage impulse to pass through the coil. After a prescribed time lapse, switch 2 is opened (mechanically, electrically or electronically) applying the correct working voltage.

Capacitor supply—initial high voltage is supplied by the capacitor discharge when the switch is closed. The series resistor reduces the supply voltage to the rated value for the coil.

Vacuum tube supply—when used as a constant-current rather than a constant-voltage source, reduces the time constant of the coil (response time) by reaching maximum current value much faster.

Quick-release circuits

Residual magnetism delays release of a clutch. There are several ways to reduce such magnetism to zero in short time.

Shunting capacitor—by selecting capacitance in relation to the average inductance of the magnet, the natural oscillation frequency can be adjusted to make the flux, hence the force, fall to zero in the desired time. (The correct capacitance can be calculated, but it is generally easier to find the value by trial and error, using a variable capacitor, then replacing with correct fixed capacitor.) By providing a zero impedance path for the coil current, the capacitor prevents an arc at the switch. The reverse magnetizing effect produced by the negative lobe of current oscillation can be made to remove any residual effect in the iron, and also to counteract the effect of any eddy currents in the iron.

Vacuum tube supply—reduces response time both in engagement and disengagement. When the coil is to be excited, the switch is thrown toward top, placing zero bias on the grid, and allowing a large plate current to flow. When release is desired, the switch is thrown to bottom, placing a large negative bias on the grid. This increases resistance of the plate circuit to a high value, quickly dissipating the stored energy in the coil.

DESIGNING A CLUTCH

Although it is the manufacturer who designs the clutch, some background information on the two groups—mechanical and electrical—of factors that influence response time may be helpful.

Mechanical

Airgap time is time required for the magnetic members to move through the gap separating them. This time is directly proportional to length of the airgap. Therefore, shortening this gap will decrease response time. However, residual magnetism of the magnetic members limits how small the gap can be. With too small a gap, residual magnetism may be sufficient to maintain coupling even in the absence of additional external energization.

The spring provides the uncoupling or the braking energy. It must be strong enough to overcome residual magnetism of the attracting faces. But a strong spring makes the coil take more time building up enough attractive force to compress it. This is especially true in brakes where the spring alone supplies energy that forces the armature into contact with the fixed opposing braking surface. A strong spring means higher brake torque; this in turn results in lower clutch torque and slower response time.

Backlash. A short time interval will be required to take up the backlash between the driving and driven members. Backlash becomes increasingly important where positional accuracy is paramount. The ideal situation, of course, is one without any backlash.

Slip. Some slippage will take place between the coupling faces as the load is being taken up. Wear on the faces may in time cause an increase in airgap. Both delay response. The clutch face should be hard and wear resistant, with a high coefficient of friction for minimum response time.

Load inertia, speed and torque. These three items are interrelated and affect response time. Slippage between the coupling faces increases in direct proportion to the magnitude of the torque, speed, and inertia of the load. Because all three require more locking torque between the coupling surfaces it is important that you recognize the capability of the unit you design into a system. In some cases a larger size device, with its increased power requirements, may be necessary.

High ambient temperature can cause a multitude of troubles which will affect response time. It may cause deterioration of the bearing lubricant and thereby introduce bearing friction or resistance to turning. It may lead to slippage by adversely affecting the friction-facing materials, causing them to harden, glaze, or burn. Mismatched coefficients of expansion may affect alignment and airgap. And the high temperature will increase coil resistance, thereby increasing the power, current, and ampere-turns necessary to produce the coupling force.

High inertia of the two armatures causes delay in the response of the one that slides.

WHAT IS AN ELECTROMAGNETIC CLUTCH?

In "Electromagnetic Clutches and Brakes for Automatic Control", *PE—Dec 19 '60, p 32*, a simple magnetic friction clutch is described this way:

"It works on the same principle as a simple solenoid-operated electric relay with a spring return to normal. Like the relay, it is a straightforward automatic switch for controlling the flow of power (in this case torque) through a circuit."

Inside the clutch two magnetic members (armatures), independent of each other and separated by a small airgap, are attached to their respective shafts. One armature is free to move axially, so that magnetic fields set up by a coil in the other members attracts the armature and engages the two shafts. Thus rotation of either shaft results in rotation of the other. When the magnetic field is removed, a spring snaps the armature back to open position.

Many variations are possible, such as arranging the spring so that the armature is normally coupled and separated only when current is applied, or anchoring the coil and one armature and having the device serve as a brake.

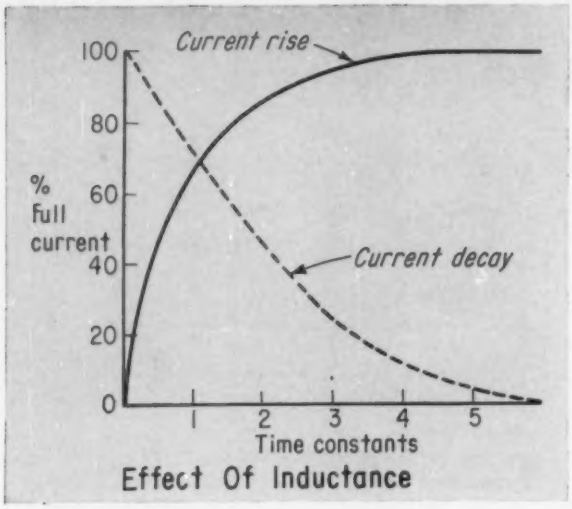
Electrical

Time constant. Because the coil of an electromagnetic clutch or brake is an inductor, the growth and decay of the current in the circuit takes time.

When the coil is energized the current cannot instantly rise to its full value because the inductance of the circuit opposes the current rise. Instead of an instant jump to full value, the current rises to full value at a relatively slow rate depending on the ratio of inductance to resistance. The time constant T in sec is L/R where L is inductance in henries, and R is resistance in ohms. After a time equal to one time constant from the start of energizing the coil, the current in the coil rises to approximately 63% of its maximum value; after two time constants, 87%; and after about five time constants, maximum current is reached. Once the current is at maximum value, inductance no longer affects the circuit. The curve of current versus time now is a straight line.

The same effect occurs when the circuit is deenergized. The counter-emf now opposes the decay of the current, which falls off at a slightly slower rate than on buildup when the coil is energized. If you try to increase the efficiency of the unit by packing more copper into the energizing coil, the inductance increases, resulting in a longer time constant. Because the inductance of a coil varies as the square of the number of turns, doubling the turns increases the inductance four times.

Eddy currents. Because iron is an electrical conductor,



Effect Of Inductance

the iron core inside the coil is effectively the secondary winding of a transformer. The coil winding acts as the primary. The lines of force from the coil cut the iron of the core and induce a voltage. This voltage causes a current flow, called eddy current, in the core itself. It circulates or "eddies" around the core, producing a slight time-lag and generating heat.

Lower core resistance means more eddy current and increased time-lag. Pure iron is used for its high permeability and low residual flux, but it has lower resistivity than annealed steel and more time-lag.

Residual magnetism. When an electromagnetic unit is deenergized, a portion of the flux in the iron core remains. In a magnetic device using a weak return spring, this residual flux (retentivity) can actually prevent the armature from releasing. A stronger spring to ensure release will require more power for operation.

Permeability and saturation. Permeability is the ability of a substance to accommodate the magnetic force. It is defined as a ratio: the number of lines of force in a material, divided by the number of lines of force in a vacuum of the same cross-section when both are in the same magnetic field. A material that can accommodate more lines of force will have greater magnetic strength, and two opposing armatures will snap together faster through the airgap separating them.

Flux density for all practical purposes is limited to the saturation flux density, or the maximum that the iron itself will carry. Any further increase in the energizing source will give very poor results for the amount of power added. But most electromagnetic devices are designed to operate at or very near saturation, so there is little the user can do to increase the magnetic strength of the unit without changing the magnetic material or the dimensions of the magnetic circuit.

For REPRINT of above article, just check P79 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: for a description of electromagnetic clutches and brakes used in control, see:
"How to Select Electromagnetic Clutches and Brakes for Automatic Control," Dec 19 '60, p 9—Design information on magnetic-friction, purely magnetic, and particle and fluid magnetic clutches. Includes sketches of 10 designs and 12 applications.

AUTOMATIC PAVER OBEYS ELECTRICAL,

DONALD R DAVIN, project engineer
Construction Equipment Div, Blaw-Knox Co

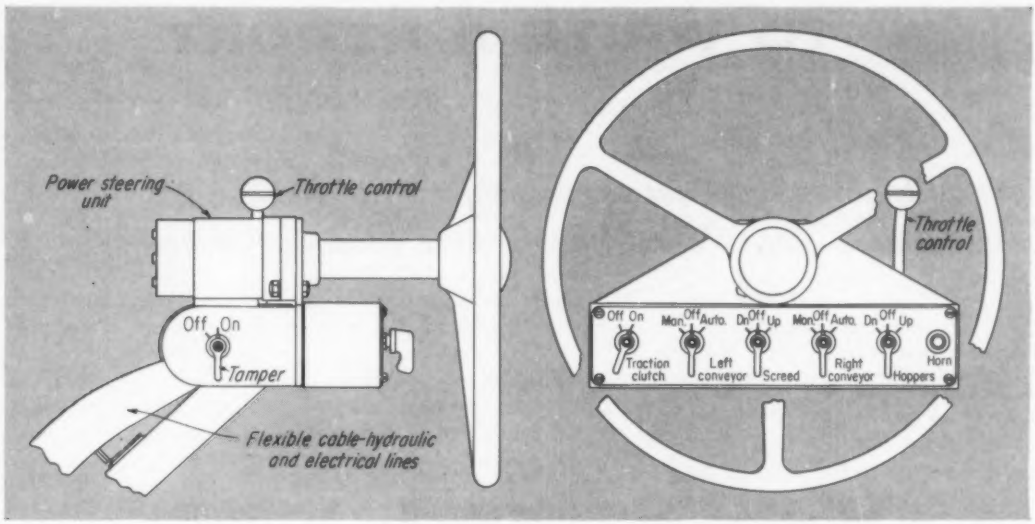
Road building has traditionally called for high skill; mechanization has been slow. But today's requirements for laying bituminous surfaces, particularly for jet landing strips, call for faster and lower-cost operation—and more precise control, too. The new Blaw-Knox PF-180 paver, shown here and on the cover, is designed to automatically control all functions including forward speed and steering of the machine, surface height and density of the mat it lays. Controls use standard components and electrical, hydraulic and pneumatic systems—each where it works best.

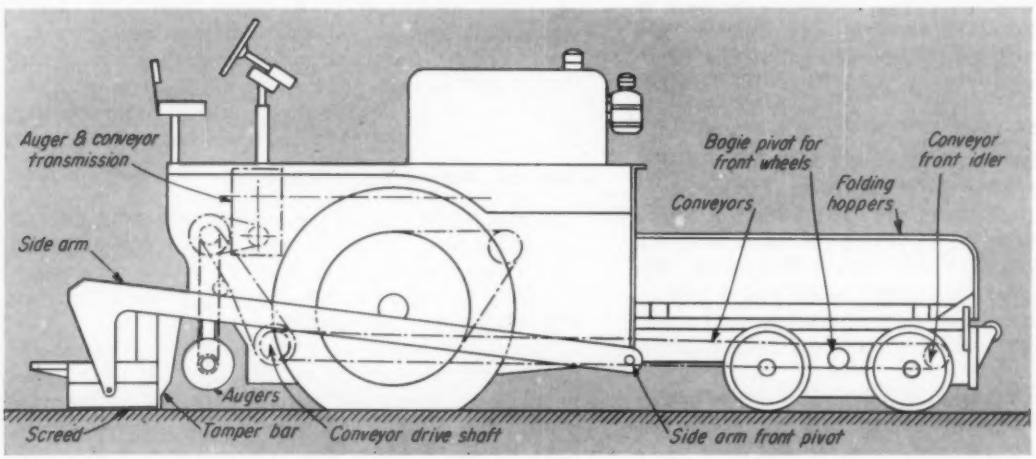
Control console is not mounted permanently but carried in pipe sockets on either side. All of its controls are electrical except for hydraulic steering, and connections are carried in a flexible conduit—a helical spring enclosed by a rubber tube.

Forward speed from the governor-controlled engine is through 10 change gears giving speeds from 16 fpm to 11 mph. Since starting is frequent, 3 to 5 times per min., drive is engaged by a diaphragm-actuated clutch with airflow throttled for controlled speed of engagement. Clutch is operated by a solenoid valve under fingertip control of a switch on the console. Power for this valve and all other electrical controls is obtained from a 12-volt generator on the engine.

Paving material (hot or cold bituminous) is placed in hopper and carried back to screed (heated levelling plate) at rear by two parallel conveyors geared to tapered cross-augers. Height of deposit delivered by each auger is controlled automatically by a paddle that rides the deposit and tilts a mercury switch controlling a 12-v solenoid valve in the air line. This air valve actuates a pneumatic clutch in the power train to each half of the conveyor-auger drive.

HYDRAULIC and PNEUMATIC CONTROLS

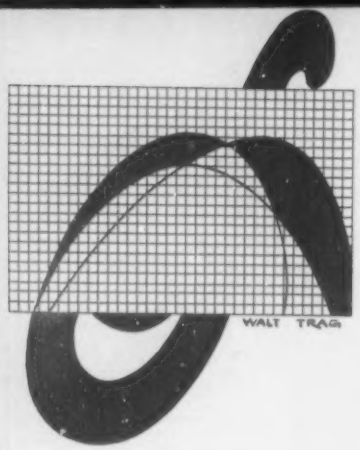




Tampers mounted just ahead of the screed compact the material. Tampers are driven at 1500 rpm by hydraulic motor from a separate 1500-psi 15-gpm pump that takes power after the traction clutch, and thus operates only when the paver is advancing.

Level control operates automatically to match height of adjoining mat, gutter or curb. A shoe riding the existing pavement engages upper or lower snap-action limit switches controlling a 4-way solenoid valve. This feeds a cylinder that raises or lowers the forward end of long side-arm which tilts the screed. Working pressure of 500-600 psi is supplied by a 1000-psi 7-gpm gear-driven pump mounted on the engine. This pump also supplies power for other functions such as screed and hopper lift, and steering.

Power steering to front wheels under the hopper is a full-power remote rotary hydraulic servo which delivers power proportional to rotary displacement of steering wheel. A flow divider in supply line from the 1000-psi pump gives steering a priority on 2 gpm. Flexible lines to steering head are ¼-ID rubber hose covered with a steel braid. Hydraulic power reduces steering effort to 8 oz and eliminates entire mechanical steering system. ■



HOW TO START TO WRITE A REPORT

Some people read to find things out; some people write because they have something to say. Why shouldn't these people get together?

J P LAIRD, *systems engineer*
Engineering Service Div, Engineering Dept
E I du Pont de Nemours and Co, Wilmington, Del

The mechanics of engineering writing, of speaking, of reading were covered in three series of articles published in PRODUCT ENGINEERING over the past two years (reprints are available—see page 87). But perhaps more important than mechanics is the attitude of the writer—confident or afraid, logical or haphazard. Here are four guideposts—basic rules for a frame of mind that can make all the difference in what you write.

Assume you have what you need

Imagine that the completed report is in front of you. You now can imagine yourself examining it in detail, reviewing its structure, content, and style. Since it is a good report, all you have to do is put down on paper what you reviewed in imagination. This sounds too simple, and you probably feel that you couldn't make it work anyway. Don't judge too soon. Don't forget, you are not learning how to write, you are learning how to enjoy being a successful report writer.

You now can shift your attention and try to answer such questions as: who will read the report; who will take action as a result of reading the report; will it be worth your time to prepare the report; will it really make any difference? To answer these questions you need to know how your report will affect others. Will it change their thinking in some useful way?

Apply the rule again. Imagine that you have just been told that a man who read the report is starting to take action as a result of what he read. Now, in imagination, you can consider who the man is and what he is going to do. You can review in imagination all the ways in which your report influences this reader.

Each time you apply the basic rule, "Assume you have what you need," you are merely visualizing how the parts of your work fit together to make a well-organized whole. If you ever get stuck while writing a report, it is probably because you are not applying the rule. More likely, you probably are refusing to apply the rule. It sounds silly; it is almost embarrassing.

You can't apply the basic rule unless you are sure that you will be successful. But now we are talking about an attitude or a belief. A man's beliefs are the hidden forces which guide his life. All successful men know they can succeed in any reasonable undertaking; they assume that success will prevail. Why don't you assume that your report will be an effective and persuasive literary masterpiece? Why not assume that you will succeed?

Assume that success will prevail

A wise person assumes that success will prevail, assumes that he has what he needs to make the success possible, and then acts appropriately to achieve the assumed success. To such a person all aspects of any problem become clear and appropriately interrelated.

It is all well and good to say, "Assume that success will prevail," but who can actually believe it? By what means does a person bring about success? Actually there are many people who secretly and unknowingly plan on failure, since in this way they can claim a near-miss of godlike success.

If you are going to apply this basic rule, apply it to first things first. You need success, therefore, assume that you have succeeded. (If you assume you will write an ordinary report, it will probably be one of the worse.) Assume your report will be an all-out success. Then apply the rule again and assume you know why it is so successful. In this way you will uncover all the features which contribute to this success.

You will find that this attitude that success will prevail comes easily when you learn to do two things: discriminate and relate.

A successful report contains information about things which differ yet are related. The report itself has sections which are different yet related. In order for a report to be

successful, it must be related, both within itself and with respect to the business organization throughout which it is distributed.

You must have the attitude that success will prevail in order to discriminate and relate effectively.

Discriminate—relate

When a man reads your writing, he will get information and mental impressions about you and the subject of your writings. Your job is to convey the precise message which you intended.

The secret lies in knowing how to do two things:

You must discriminate. You must find out how to distinguish the one idea which concerns you at a specific instant from all other ideas. There are always distinguishing features which will discriminate any one idea. Your writing at that one point will become specific and very much to the point.

You must relate. In this way you reassemble the ideas, which were discriminated for clear identification, into a meaningful whole entity.

Consider a few illustrations of improper discrimination and relationship. You have a report on a new machine. You are reading a description which tells about the physical layout of the assemblies, when suddenly you discover that you are reading about how the machine functions or why it saves money. In another case you may be reading about a basic principle in mechanical engineering only to discover that at some past point the author switched without warning to a specific example. The confusion in these examples is typical of the failure to discriminate and relate. This is the cause of most bad report writing.

You may have realized that you cannot discriminate without relating. For example, the difference between "pencil" and "pen" cannot be established without relating each to "paper" by means of "writing." In this example you would not bring in nonessential similarities, such as "carried in pocket," because this would not aid in discrimination. You would, however, bring in differences such as "solid lead" *vs* "liquid ink" and "erasable" *vs* "cannot erase what has been written."

Your job is to relate and discriminate at the same time. You choose that relationship which helps to discriminate.

Note that everything you write or say either discriminates or relates. You may be describing an additional difference or distinguishing feature of some plan of action or you may be relating this plan to the probable success of the company. Try to distinguish between discriminating and relating, then combine the two so that they reinforce each other and lock together.

There are a number of distinct areas in which you must discriminate and relate. Each of these areas has its own peculiar requirements. Proper discrimination and relationship are important within each area. It is even more important for you, as writer, to know which area you are dealing with and not jump from one area to another without orienting the reader quite carefully. These broad areas are listed below.

Point of view and motivation. You have reasons for writing; the reader has reasons for reading. You want to derive the satisfaction of producing a report which is well received. Many readers will give you this satisfaction if you will discriminate your own selfish motivations, eliminating as many as possible, and relate everything in the report on a reader-interest basis.

Organization of report. Be able to discriminate:
abstracts, resume, summary, table of contents;
appendix, exhibit, attachment;
table, graph, figure, illustration, diagram, sketch, schematic;
discussion, section.

Subject matter and its relationship. Be able to discriminate:
ambition, belief, objective;
theory, hypothesis, assumption, principle (for example, scientific principle vs moral principle);
attitude, behavior;
method, procedure, means;
intent, outcome, results, significance of results;
hope, plan, accidental discovery;
data, information, facts, knowledge, understanding, wisdom;
definition, description, example, illustration;
opinion, conclusion, recommendation, proposal.

Requests and proposals. If you haven't got a proposition, you don't have anything to say. Your proposal should be specific. For example, a progress report should clearly indicate progress from a stated starting point toward a stated objective and should propose continuation of the work as planned or modification of plans for stated reasons. Informational reports should specifically state that they will be useful as reference material and should tell why. Some reports are spoiled by subtle demands for praise or recognition of the author at the expense of the reader. A successful report makes proposals which will be of benefit to the intended reader.

Writing is an art, there is nothing routine or mechanical about it. You will want to think about this matter of discriminating and relating, and then practice your best when you write. It takes real creative effort to combine theory, ideas, facts, and calculations into a good report. Why not try to make it a work of art while you are at it.

Attack each job as a creative and artistic act

Every artist works solely for his audience. A good artist learns how to use his tools. He discriminates between tools, and he relates the tools to the job at hand. He discriminates between audiences, and he relates his work of art to his audience. He feels a deep conviction that his chosen audience will appreciate his work of art.

The quality of an artist is measured in terms of the audience which is influenced by his work and how that audience responds.

The next time you write, consider it to be a creative and artistic act. Assume that success will prevail. If any part of the over-all presentation is missing or is hazy, assume you have what you need. You will then be able to create this difficult portion by systematically relating specific thoughts which are distinct yet connected. Because you have kept the reader in your mind at all times, you will tell your story to him in such a way that he stays interested. You will have condensed and clarified your writing to make all parts stand out in proper relationship. You will have created a work of art, pleasing to the eye, the mind, and the heart of the reader. ■

nine lectures on MECHANISMS

1...SPRING MECHANISMS–force analysis
2...SPRING MECHANISMS–point balancing
3...SPRING MECHANISMS–continuous balancing
4...POWER CYLINDER MECHANISMS–full stroke
5...POWER CYLINDER MECHANISMS–intermediate positions
6...FEEDER MECHANISMS–types
7...FEEDER MECHANISMS–applications
8...FEEDER MECHANISMS–angular motions
9...FEEDER MECHANISMS–curvilinear motions

4...POWER CYLINDER MECHANISMS– full stroke

KURT HAIN *Institute For Fundamental Research, Brunswick, Germany*
Translated by Prof. F. R. E. Crossley, Yale University

Choosing the right proportions for mechanisms requires balancing opposing factors. This discussion and the charts tell how.

For efficient transmission of forces from power-driven cylinders, a mechanism must be designed so the moment of the output load on the piston is as constant as possible. But a number of forces may act on the mechanism's links, independent of the normal output load. These forces must be analyzed and evaluated in order to determine the proper proportions of each link. When more than one output load is connected to the mechanism, each one must be considered independently. To minimize peak loads on the piston, the mechanism must be designed so that its variable velocity ratio will give minimum side thrusts. Where a number of linkages can fulfill the requirements, two parameters are particularly useful in evaluating the choice: the transmission angle μ, and the side-thrust angle σ (see Fig 1).

Comparing the two cylinders in Fig 1 shows that the best transmission angle μ is 90 deg; the worst, either zero or 180 deg. Fig 1(B) shows that the best possible side-thrust angle σ is zero, and that any increase in this angle creates a transverse-force component which results in friction losses in the power-driven cylinder. The most advantageous combination of transmission and side-thrust, angles will be between these extremes.

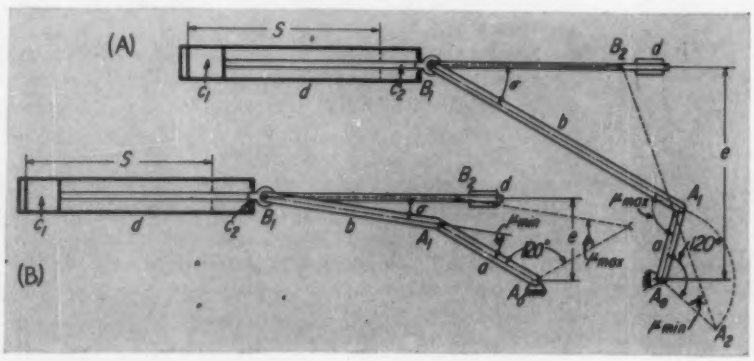
Two sets of curves, Fig 2 and Fig 3, show how to pick the right combination of angles. The curves are more easily understood by considering typical examples.

Angle of swing without intermediate positions

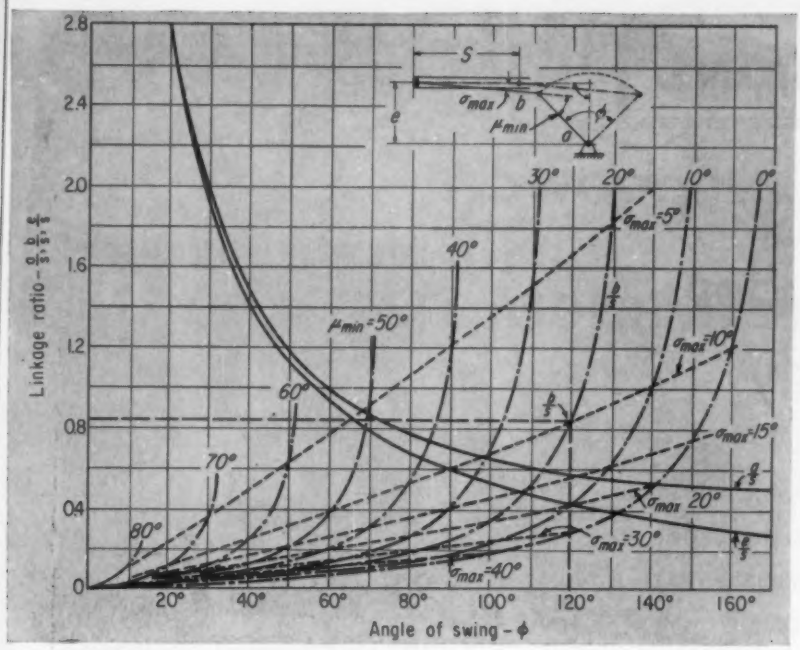
In Fig 1, cylinder d with a given stroke is required to give an output swing of 120 deg. Two possible linkages are shown. Linkage 1(A) gives advantageous transmission angles of μ_{min} and μ_{max}, but the side-thrust angle is too large. Linkage 1(B) represents an improvement; transmission angles were selected from Fig 2, from which the side-thrust angle and linkage proportions were also determined. From curves in Fig 2, angle of swing $\phi = 120$ deg gives $\mu_{min} = 20$ deg and $\sigma_{max} = 10$ deg. Intersection of these two curves, gives the ordinate ratio $b/s = 0.83$, which determines the length of the connecting rod b for a given cylinder stroke s. The ordinate for angle $\phi = 120$ deg intersects the curve a/s to give 0.57, and the curve e/s to give 0.42. Thus, the length of connecting rod a and the offset e are readily determined for a given cylinder stroke.

Even if the force produced at the piston in the linkage were constant, it would still be impossible to make an exact prediction concerning the variable moment produced to turn the driven connecting rod a. We can, however, pose this problem: For a 120-deg output angle and a constant piston force, let the turning moment of the output lever be as nearly constant as possible. Because the mechanism has an inherently variable mechanical advantage (velocity ratio), it will never be posssible to produce a moment at the output lever which is mathematically constant. But the best linkage will be the one that produces a turning moment with an acceptably small variation from a desired constant.

For this selection the curves in Fig 3 are used. Each curve δ in the series indicates the percentage above or below the



1. THE OPPOSING PARAMETERS must be balanced to make the most efficient use of levers with power-driven cylinders. Best combination would be high transmission angle μ, and low side-thrust angle σ; but this is not possible. In (A) both of these angles are large; in (B) both are small. Best result lies somewhere in between; charts on facing page show how to compromise.

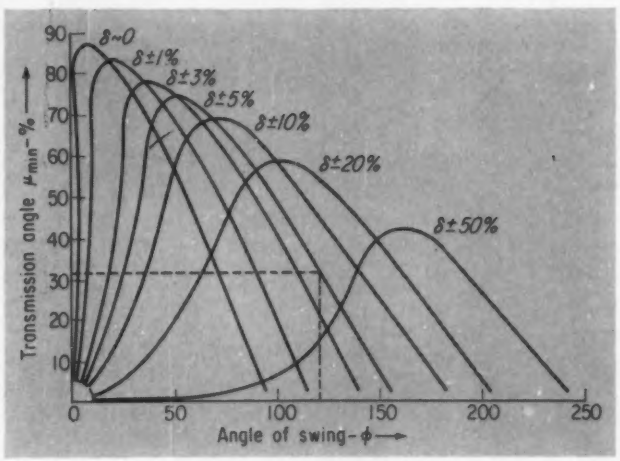


2. LINKAGE RATIOS for the various output angles of swing can be determined from this graph for various transmission and side-thrust angles.

constant moment desired for various values of ϕ and μ_{min}. For any given angle of swing ϕ any number of transmission angles μ_{min} are possible, but at the same time we also want to get the minimum deviation from a constant output turning moment. For example, if we allow a maximum deviation $\delta = \pm 5\%$ from the desired constant turning moment, then for an output swing of 120 deg, the worst transmission angle $\mu_{min} = 31.5$ deg. On the other hand, if the transmission angle is greater, the deviation δ must be allowed to increase. This accents the opposing characteristic of these two parameters and requires a suitable compromise, which will give a maximum transmission angle for a minimum deviation δ. The curves in Fig 3 show what choices are possible in this respect.

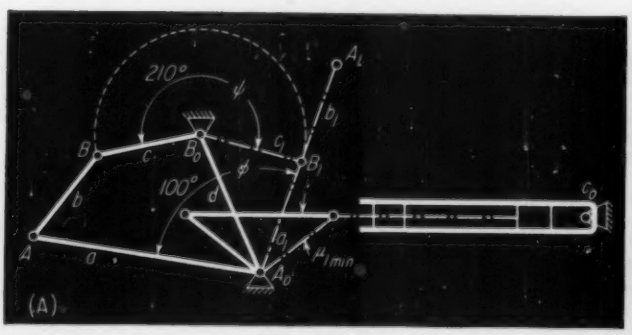
To overcome this limitation on angle ϕ, the arrangement in Fig 4(A) shows the cylinder pivoted at C_o and the piston rod attached to connecting rod a_1. The maximum practical angle of swing ϕ is 100 deg, which gives a corresponding transmission angle μ_{1min} of 40 deg. However, this angle of swing can be used to produce a much greater output angle of swing ψ by compounding a second four-bar linkage with links *a*, *b*, *c* and *d*. The output lever c swings about the fixed journal B_o, and the secondary transmission angle μ_{2min}, can be made equal to μ_{1min}, the angle between the coupler *b* and the lever c. This results in an output angle of 220 deg for an input angle of 100 deg.

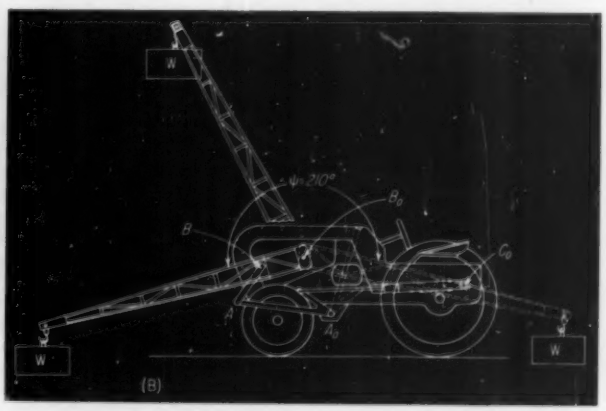
Fig 4(B) shows how this four-bar linkage can be applied to a mobile crane. The load arm is integral with the output lever c of the mechanism, and its large output angle makes it possible to handle loads in front as well as behind the tractor.



3. THE TRANSMISSION ANGLE determined from previous graph can be checked with this graph for minimum deviation when a constant turning moment is desired.

REPRINTS: The nine articles in this series will be available as a combined reprint for $1.00 after the series is complete. Address: Reader Service Department, Product Engineering, 330 W 42nd St, New York 36.

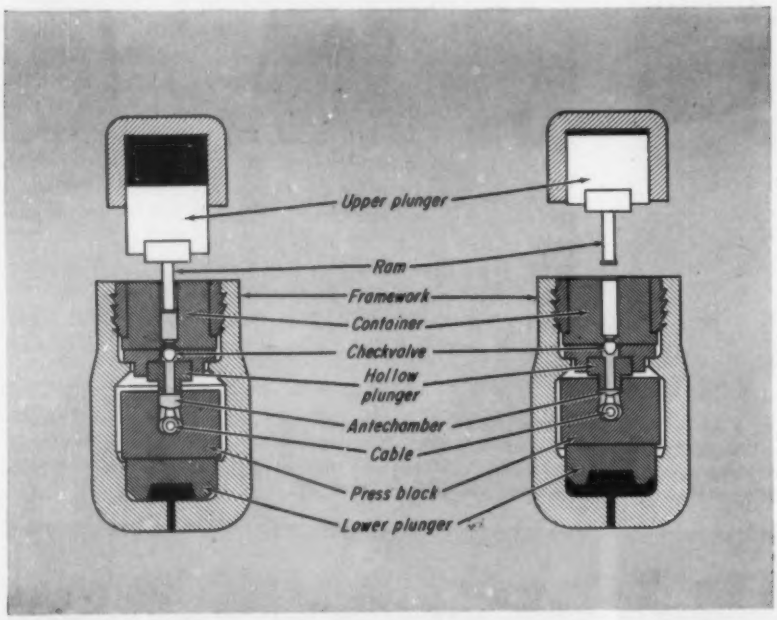




4. FOUR-BAR LINKAGES as developed in *(A)* can increase the range of output angle from 100 to 210 deg with a favorable mechanical advantage of the power transmission. This linkage is incorporated in the mobile crane *(B)*.

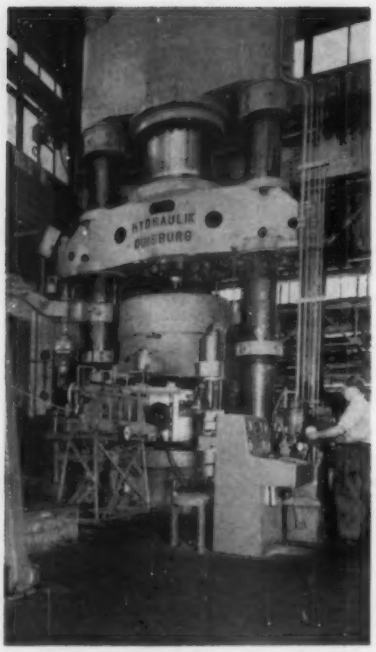
2-way Press Extrudes Metal Continuously

It eliminates junctions that produce weak spots in aluminum cable-sheathing. During refill, press block rises and continues to extrude part of old charge as plunger forces in new one.



EXTRUSION BEGINS as the upper plunger and ram move downward into the billet container. First, ram forces an aluminum sealing disk into the container, which is then evacuated to prevent air bubbles from being included in the extruded sheath. Downward movement of the ram forces aluminum past the checkvalve, through the hollow plunger into the antechamber, and then to the dies that form the sheath. As the billet container empties, water at pressure is introduced into the lower cylinder to force the press block upward. This in turn, forces aluminum up against the checkvalve, sealing lower end of the container and allowing ram to withdraw. As press block rises, it maintains pressure against the hollow plunger and continues to extrude aluminum from the antechamber, producing a continuous flow to the sheath-extrusion dies.

Volume of aluminum in the antechamber is sufficient to keep the press running, at a reduced rate, while a new billet is installed. When the charging cycle is completed, pressure in lower cylinder is slowly reduced and aluminum is again forced down from the container, through the checkvalve, to refill the antechamber.

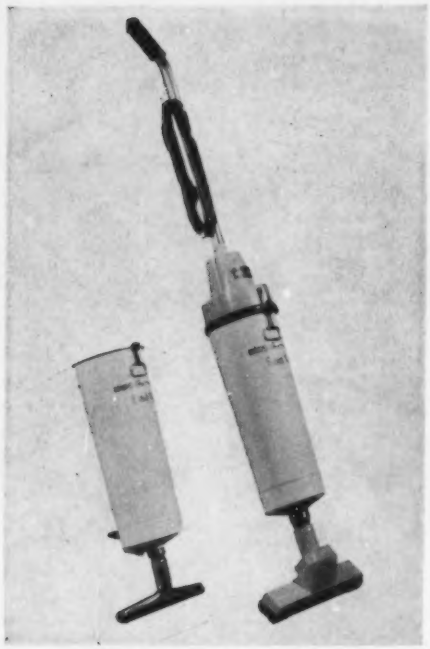


PRESS EXTRUDES aluminum sheath directly onto cable in a continuous process, so there are no press marks or junctions. Checkvalve in the charge container retains a portion of the charge for extrusion during the recharging operation. Complete die chamber is raised hydraulically, at conclusion of ram stroke. This closes the checkvalve and continues the extrusion at reduced rate during the time the ram is withdrawn from the container and a new billet inserted. Preheated aluminum billets weigh 200 lb, require approximately 40 sec to place in container of the press.

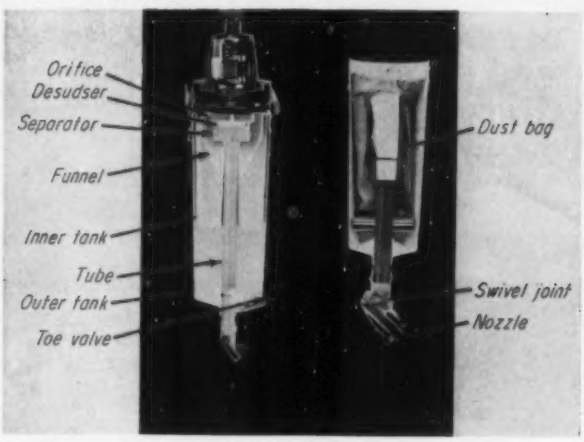
PS . . . Extrusion press produces unbroken lengths of aluminum- or lead-sheathed high-tension or coaxial cable. Junctions in such cable sheathing are undesirable; they tend to kink when the cable is bent and can result in cracks or leaks. Extruder is a modified 3800-metric-ton press which can sheath cable varying from 0.195 to 2.75 in. dia. Produced by Hydraulik Gmbh, Duisburg, Germany.

Sweeping or Scrubbing—Motor Stays High and Dry

Power unit clips on top of interchangeable tanks that pick up dust or dirty scrub-water. Housing separates suction fan from motor; small fan inside does the cooling.

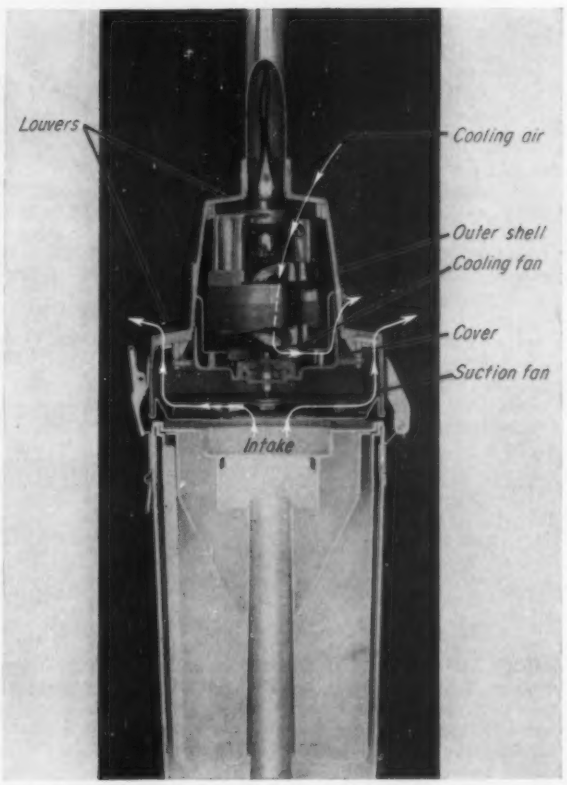


CLEANER TANK picks up dry dirt from rugs and floors. Suction generated in tank pulls dust-laden air through nozzle and central tube into dust bag. Bag filters dirt from the air, which is discharged through power head. Either reusable cloth or disposable-paper dust bags are used.



SCRUBBING TANK is designed to wet, scrub and dry hard-surface floors. Outer tank holds cleaning mixture, inner tank receives dirty water sucked up by power head. Cleaning mixture is dispensed from outer tank by toe-operated valve. Dirty water flows up central tube, strikes replaceable de-sudser cake in separator and flows down to inner tank. Funnel in inner tank prevents dirty water from being splashed out of inner tank by scrubbing action. Air escapes from scrubber through orifice in upper chamber of separator.

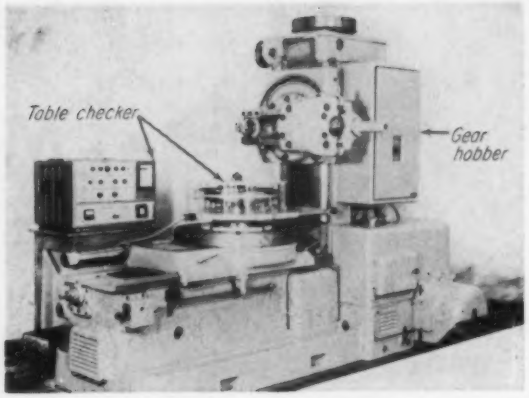
PS . . . Lightweight scrubber-cleaner uses high-speed centrifugal blower to reduce air pressure at pickup nozzle and pull dirt up central tube. Scrubber has de-sudsing cake and separator to remove bubbles from dirty water. Sweeper collects dirt in reuseable cloth or disposable dust bag made of paper. Motor is a 110-v, 250-watt, 1/5-hp series-wound unit running at 14,000 rpm with a ¾-in. inlet. Bissellectric Sweep Master–Scrub Master combination *(also see Jan 16 issue, p 24)* is by Bissel Inc, Grand Rapids, Mich.

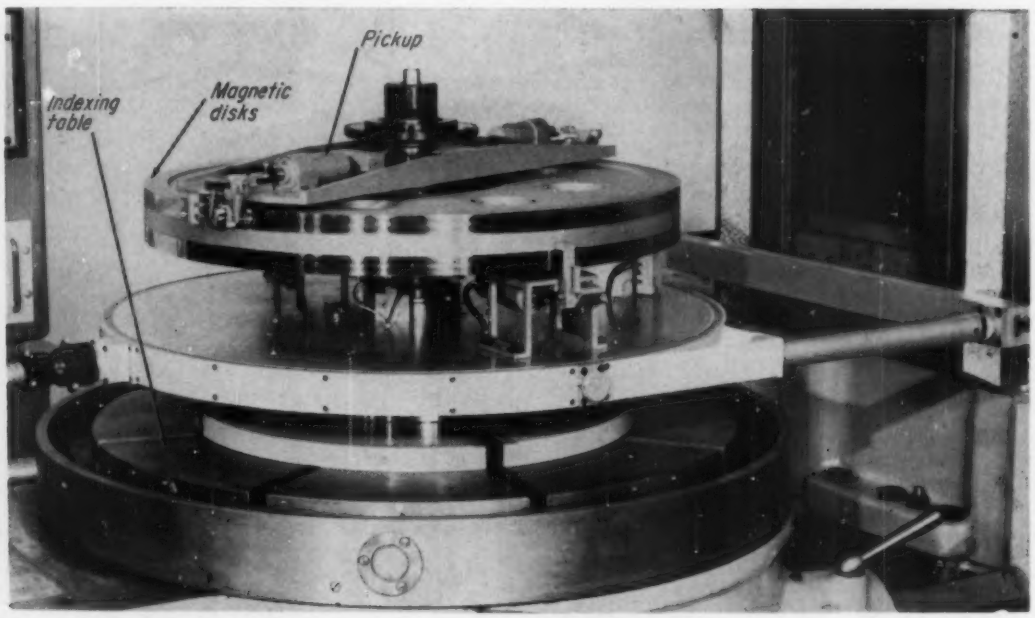


MOTOR HOUSING is designed to keep motor dry without the watertight enclosure normally required with single-fan designs. The cover separates the motor from the incoming dirty air or water. A small fan above the cover cools the motor by pulling in air through top louvers down airgap, around rotor and out through a vent in side of outer shell. The main suction fan, located below the cover, pulls air through a screened intake and discharges it through lower louvers. Outer shell is one-piece die-cast aluminum, serves as motor mount and fan enclosure, and provides attachment for handle and scrubber-cleaner canisters. Louvers reduce noise of air discharge and direct stream away from handle and operator.

Double Correction Produces Better Gears

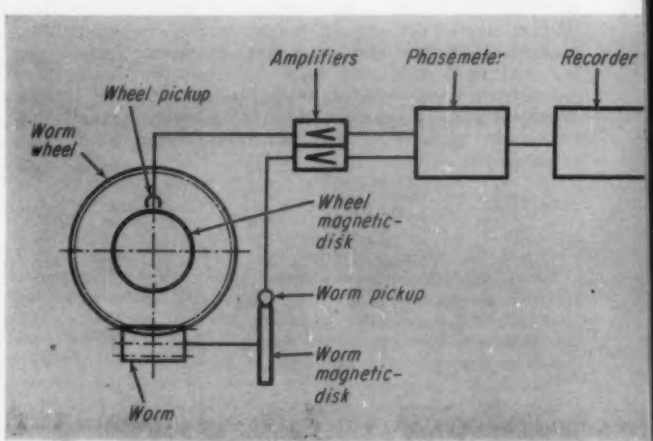
Automatically compensating the indexing gears plus precise measurement of their variations gives less gear-hobbing error, permits producing gears with tolerances held to as little as 1/1,000,000 mm.

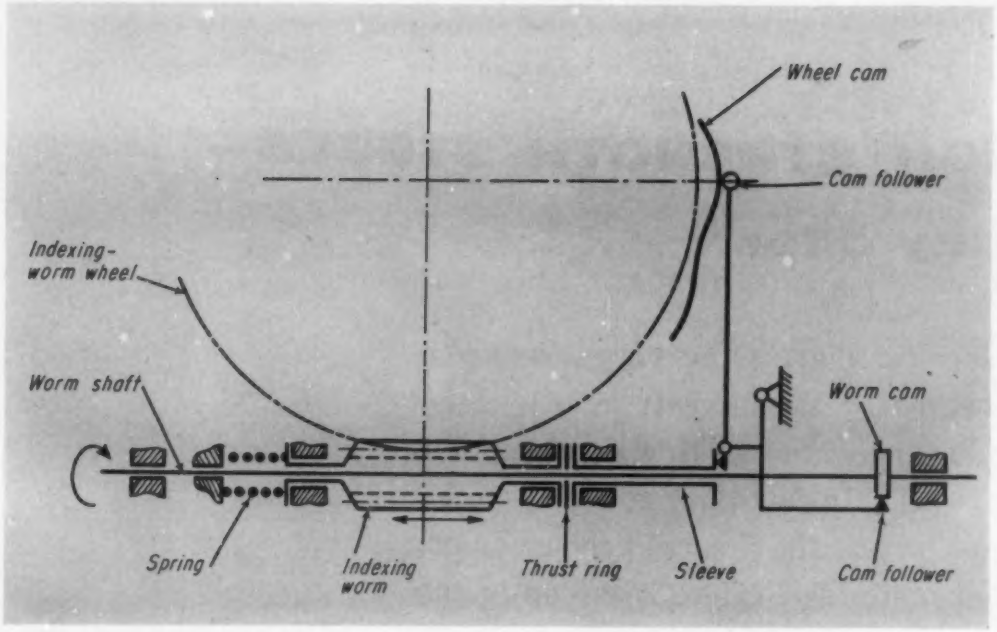




CIRCULAR MAGNETIC DISKS in table-checking device produce a curve that measures angular deviation of the measured table drive from an ideal drive. This error is sum of errors produced in the gear train that drives the indexing table. The measurements include the error repeated in every revolution of the indexing table and the cyclic error which occurs with every tooth.

Magnetizable disks on which are recorded magnetic waves of equal length are mounted to the worm and worm wheel (or index table). As the transmission revolves, an electric voltage of given frequency is induced in magnetic pickups. A perfect indexing mechanism produces identical frequency and phase shift from each pickup. Inaccuracies produce phase deviation of the generated signals which are indicated by a phasemeter and recorded. Errors of less than 1 sec of angle can be detected during machine operation. The recorded deviations are used to produce corrective cams that are then incorporated in the indexing-drive system.

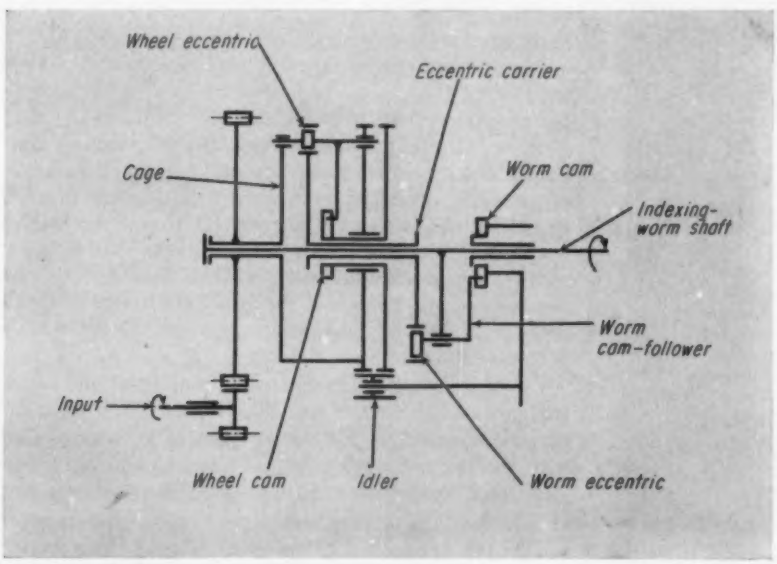




(A)

GEAR-HOBBING ACCURACY depends on precision of the kinematic chain formed by the hob, hob-drive gears, and indexing-table drive gears. Largest source of deviation is the worm-wheel drive of the indexing table on which is mounted the gear being cut. Improved accuracy of this drive comes from increasing precision of its gears and from corrective drives which continuously compensate for inaccuracies in adjoining pitch circles. In application of a corrective indexing drive to the worm, both axial shifting and variable speed are used. Both methods use corrective cams produced from deviations recorded by the corrective device.

Axial displacement of the worm (A) is produced by balanced levers controlled by two cams. Movement of the two cam followers is integrated into a single axial movement by interconnecting the actuating levers. Variable-speed control of the worm (B) is obtained by a system of eccentrics positioned by a pair of cams representing the required corrections for worm and wheel. Input of the variable-speed corrective system drives a cage which rotates the wheel cam by means of an idler. The wheel-cam positions the wheel-eccentric mounted on the cage to vary angular position of the eccentric-carrier. The worm-eccentric, also mounted on the eccentric carrier, is positioned by the worm cam. The sum of these angular corrections is transmitted to the indexing worm shaft by the follower which connects the worm cam and its eccentric. Advancing or retarding the drive worm compensates for variations in the indexing system recorded by the table-checking device.



(B)

PS . . . Indexing-table checker will work with existing gear-hobbing machines to check accuracy of the table-drive gears, and its visual record can be used to produce cams for self-correcting drive systems. New gear hobber incorporates these drive mechanisms, which employ cams to compensate for errors in both the worm gear individually and the entire gear train. IMO-200 table-checking device and IMO-S gear hobber are distributed by Strojimport, Prague, Czechoslovakia.

A PRODUCT ENGINEERING SPECIAL REPORT

THE HIGH-STRENGTH STEELS— what they offer

Some of them are familiar. Others are newer compositions, pioneered by the aircraft industry, that are finding wider applications. How much more do they give you in psi? In favorable strength-weight ratio? And just what's the practical choice among these important materials? Here is the up-to-date story, along with a comparison table for quick reference.

HERBERT L KEE
Assistant Editor

Meaning of "High" and "Low"

The words "high" and "low" can refer to strength of the material. But they also, of course, can refer to the percentage of alloying elements. The matter of high and low strengths is easy—that's simply a matter of stating psi. It is the composition sense that causes the most confusion.

If you are in the steel industry, "low alloy" means the high-strength steels for construction purposes—beams, girders, etc. These steels have a low percentage of alloying elements.

And "high alloy" designates a stainless. In the same industry are steels intermediate in alloy percentage. These, which are alloyed to permit heat-treating for strength, are simply called "alloy steels." This category includes the familiar 4340.

If you are in the aircraft industry, you'd call the same 4340 a "low alloy" steel simply because it has lower alloy than most of the steels you normally use. In other words, it's being used in the relative sense. Similarly with "high alloys"—again relative. This is another term for the so-called "superalloys." The percentage of their nickel or cobalt base is so high that they aren't steels at all.

The extra muscle offered by high-strength steels opens new fields of application. But that isn't all. They can also influence designing for standard applications. Here, these steels are an outstanding example of how a single property of a material can bring a chain of benefits. The extra strength is immediately reflected in the opportunity to reduce weight of a structure. In other words, the formula becomes: less weight for same strength. And a better strength-weight ratio in turn means the chance to lower costs.

Furthermore, we are dealing here with a dynamic situation. Usefulness of the high-strength steels is constantly being broadened by new additions to this family of materials. Many of these steels were originally limited to special jobs, such as in aircraft. They are now finding work in everyday high-strength applications—shafts, bolts, springs, pressure vessels and the like. This reaching-out has been speeded because the expensive-to-test property data demanded by designers in the special fields have become available to other industries.

Generally, a high-strength steel is considered one whose strength exceeds that of low-carbon steel. This, however, covers a wide range. For convenience, it is better to deal with the two main categories: (1) the high-strength constructional steels with yield strengths 1½ to 3 times that

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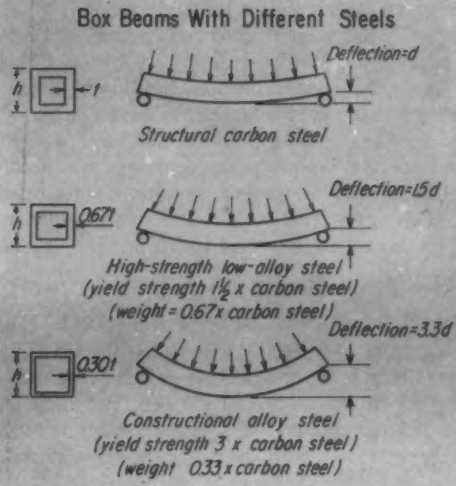
When strength means money saved

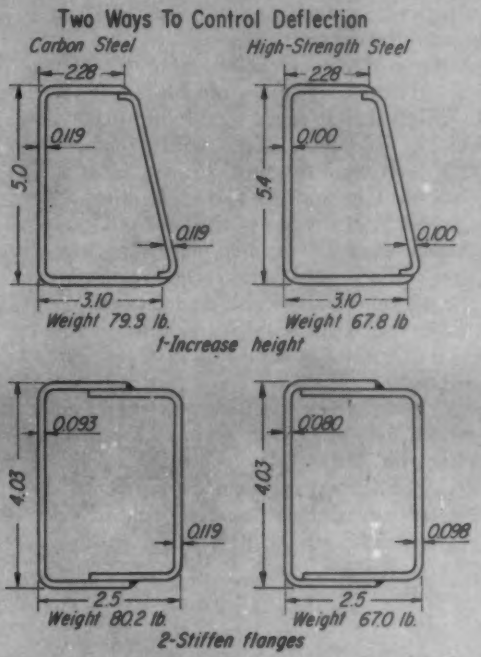
In fabricated structures, here's how a steel with higher yield strength allows savings in cost of the basic materials. The simple box beams illustrated below are good examples. Strength in bending is proportional to the yield point; a higher yield point allows you to decrease thickness of material in the same proportion. With a given elastic modulus, deflection is directly proportional to the yield point.



For box-shape members with equal bending strength and depth, weight of a high-strength low-alloy steel member (45,000 psi yield) is ⅔ lighter than that of carbon steel (30,000 psi yield) but deflection is 1½ times as great. For the alloy steels (100,000-psi yield) weight is reduced by ⅞ and deflection increased to 3.3 times that of a carbon-steel beam.

Where deflection limits require that high-strength members bend no more than carbon-steel members, the former must be so designed that material is distributed to give the same moment of inertia as the weightier carbon-steel shape. This means placing the high-strength metal further from the axis of the beam and generally results in adding some material to the section. Cost savings therefore are less than in a structure where deflection is not a limiting factor.

Two ways to keep deflection in high-strength beams equal to that in carbon-steel beams are also illustrated here. Top shows a structural member deepened so that moment of inertia can remain the same though the material is thinner. Bottom shows how material is redistributed into overlapped areas at top and bottom to stiffen the structure without adding height. Note that thickness in inner flange has been reduced more than thickness of the outer flange.



of carbon steel; (2) the high-strength alloy steels with as much as 10 times the yield strength of carbon steel.

THE CONSTRUCTIONAL STEELS

The high-strength constructional steels can in turn be divided into two groups: high-strength low-alloy steels and constructional alloy steels.

High-strength low-alloy steels

These have yield points from 45,000 psi to 60,000 psi and do not require hardening. Their yield points (1½ to 2 times that of structural carbon steel) allow a one-third to one-half reduction in thickness of material without sacrificing its ability to carry tensile loads. This saving in material can also be had in beams stressed in bending, if higher deflection can be tolerated.

Relatively short members under compression loads show a reaction similar to that of tensile members. But long compression members or columns will collapse or buckle when the critical axial load is exceeded—the longer the column, the sooner this point is reached. To prevent buckling, thickness of material is increased. In compression, therefore, cost of material does not show any advantage for the high-strength steels over carbon steel. See table on next page for over-all comparison.

Endurance limit of the high-strength steels goes up in proportion to gain in ultimate tensile strength. (Steels below 200,000 psi ultimate have a ratio of endurance

limit to ultimate strength of about 0.5.). However, a better value for endurance limit would be that taken on riveted or welded section of as-rolled plate. These notches more nearly approach those in actual structures, and fatigue strengths from these notch tests are often lower by 25% or more.

Notched impact resistance is about ½ higher than that of 1010 mild steel. Moreover, the transition temperature from ductile-to-brittle fracture is shifted 100 degrees lower in the low-alloy steels. This means that these low-alloy steels can be used outdoors in cold climates without becoming severely notch-sensitive. SAE 1010 steel, by contrast, becomes impact-brittle below 30 F.

Ductility in the cold-forming grades with 45,000 psi yield and 25% or more elongation, roughly equals that of mild steel. The higher strength steels with 50,000 to 60,000-psi yield are less ductile; their forming properties resemble those of the carbon structural steels.

Both low-alloy steel groups allow cold forming with the same equipment and procedures used for mild steel, though the higher strength requires somewhat higher forming pressures and additional allowance is required for springback. Die clearances also must be increased. The cold-forming grades can be bent to an inside radius equal to the thickness if material is under ⅜ in. Plate over ⅜ in. requires 1½*T* radius.

The stronger grade steels need larger bend radii. Minimums are: 1*T* for sheet up to ⅜ in.; 2*T* for ⅜ to ¾ in., 3*T* for plate over ¾ in.

Bending is somewhat easier when perpendicular to the rolling direction, and all cold forming should be done at temperatures at least 60 F. Hot forming for sharper bends, and other more severe working, can be done above 1200 F.

Good weldability is imparted by low carbon content and composition which balances small amounts of different alloy elements. The high-strength low-alloy steels can be welded both to lower strength structural carbon steels and to the stronger, constructional alloy steel. This permits wider choice in design—keeping the cross-section constant, with efficient butt welds, and meeting strength requirements with different materials. In general, the low-alloy steels can be welded with mild-steel electrodes, giving strength at the joint equivalent to the base metal. This is because enough alloying elements dissolve from the base metal to improve weld-metal strength.

Corrosion resistance of the low-alloy steels is generally several times better than that of carbon steel. The steels alloyed with chromium and nickel, such as Cor-Ten, have 4 to 6 times the corrosion resistance while the steels strengthened by manganese additions have about twice the corrosion resistance. The adherent dense rust prevents undercutting of paint coatings—no need for such surface-conversion coatings as phosphating or chromating. This protective oxide also reduces need for surface cleaning when the steel is repainted.

The constructional alloy steels

These have tensile yield strengths of 80,000 to 110,000 psi. Of the group, US Steel's T-1 steel is the best known. The high strength is obtained by water-quenching and tempering which leave residual stresses (but these cause distortion if large amounts of stock are machined away).

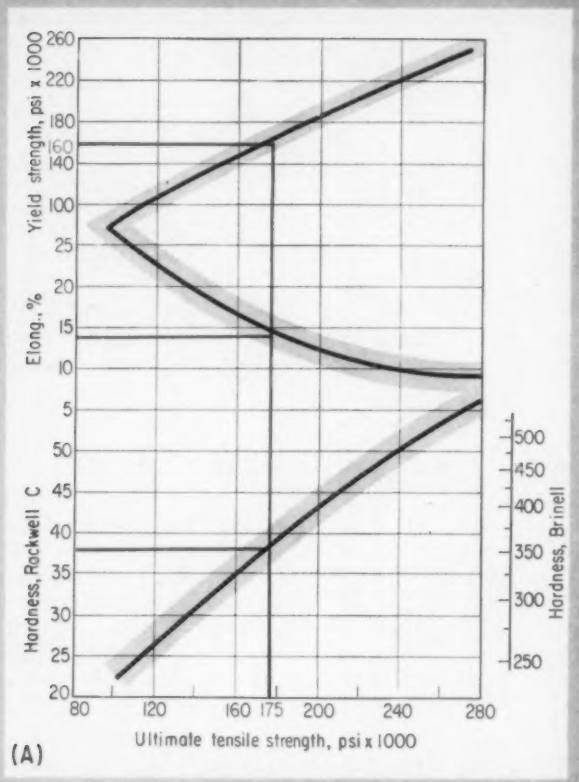
Ductility is lower than for the low-alloy steels and

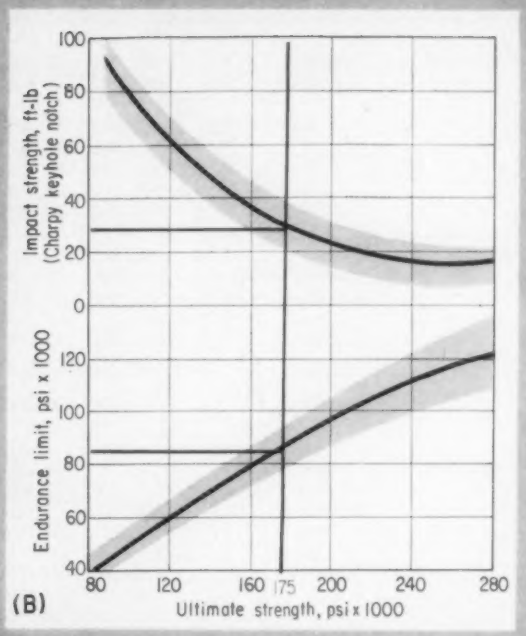
—Strength and cost—
Constructional high-strength steels vs carbon steels

Steel	ASTM Designation	Min Yield Point, psi	Base Price, ¢ per lb	Strength-cost Ratio: Tension members, short columns, and beams	Strength-cost Ratio: Long columns
Carbon steel for bridges and buildings	A 7	33,000	6.40	1.00	1.00
Carbon structural steel (welding grade)	A 373	32,000	6.60	0.94	0.97
Improved carbon structural steel	A 36	36,000	6.45	1.08	0.99
High-strength steel (U. S. S. Man-Ten)	A 440				
¾ in. and under		50,000	7.4	1.31	0.86
¾ to 1 ½ in.		46,000		1.21	0.86
1 ½ to 4 in.		42,000		1.10	0.86
High-strength low-alloy steel (U. S. S. Tri-Ten)	A 441				
¾ in. and under		50,000	8.4	1.15	0.76
¾ to 1 ½ in.		46,000		1.06	0.76
1 ½ to 4 in.		42,000		0.97	0.76
High-strength low-alloy steel (U. S. S. Cor-Ten)	A 242				
½ in. and under		50,000	8.7	1.11	0.75
½ to 1 ½ in.		47,000		1.05	0.75
1 ½ to 3 in.		43,000		0.96	0.75
Constructional alloy steel, heat-treated (U. S. S. "T-1")		100,000	15.5	1.25	0.41

Courtesy: US Steel

When specifying an alloy steel





Strength properties can be specified by hardness if an alloy steel is fully hardened to martensite before tempering. Alloying elements present make little difference in room-temperature properties as long as the steel contains sufficient alloy content for through-hardening.

The accompanying charts are for steels with 0.30 to 0.50% carbon, a range that covers most of the hardenable engineering steels.

For instance, when the requirement is 160,000 psi yield strength, start at the top left of chart (A). Intersection with top curve gives ultimate tensile strength of 175,000 psi. Then go down along 175,000 ultimate. Intersection with second curve gives elongation of 14%. Continuing to the third curve gives a hardness of RC 38 which provides a means for specifying yield, ultimate and elongation. From chart (B) follow line for 175,000 ultimate and determine endurance limit, 87,000 psi, and Charpy notch impact strength, approximately 30 ft-lb.

cold forming is more difficult. Springback is about 3 times that of carbon steel and minimum bend radii must be increased to 2*T* for material thickness under 1 in. and 3*T* for plate between 1 and 2 in.

Hot bending will give smaller radii but working temperatures should not exceed 1100 F. If more severe working is necessary, these steels can be annealed. After working they must be reheat-treated by a water quench from 1700 F followed by a temperature of about 1200 F.

Welding the constructional alloy steels is more difficult than the low-alloy ones. Arc welding is best because rate of cooling from weld temperature is adequate to reharden the part. These steels require low-hydrogen electrodes because they are prone to cracking under the weld bead. This means that the normal precaution—heating low-hydrogen electrodes to keep them dry—must be followed. When welding restrained parts, a further precaution is required—limit the heat input per inch of weld. Weld preheat is generally not needed.

text continued, page 59

Properties and composition of the HIGH-STRENGTH LOW ALLOY STEELS

Producer	Alloy	Yield Point, psi	Ult. Strength, psi	Elong., %	Nominal Composition, % C	Mn	Si	Cu	Mo	Cr	Ni	Other
Alan Wood Steel	Dynalloy I	50,000	70,000	22	0.15	0.80	0.30	0.45	0.10		0.55	
	Dynalloy II	45,000	62,000	25	0.15	0.80	0.30	0.45	0.10		0.55	
Armco Steel	High Strength No. 1	50,000	70,000	22	0.15	0.70	0.15	0.60			0.75	
	2	45,000	64,000		0.15	0.70	0.15	0.60			0.75	
	3	40,000	60,000	35	0.10	0.60	0.10	0.20				0.02 V
	4	50,000	70,000	22	0.25	1.35	0.25	0.20				
	5	45,000	60,000	25	0.22	1.25	0.30	0.20				0.02 V
Bethlehem Steel	Mayari R	50,000	70,000	22	0.12	0.75	0.55	0.50		0.70	1.0	0.10 Zr
	Medium Manganese	50,000	75,000	20	0.25	1.35	0.30	0.30				
	Manganese Vanadium	50,000	70,000	22	0.22	1.25	0.30	0.20				0.02 V
Crucible Steel of America	Maxeloy	50,000	70,000	22	0.15	1.20	0.50	0.20			0.50	
Colorado Fuel & Iron	Clay-Loy	50,000	70,000		0.22	1.25	0.35	0.50				0.2 V
Inland Steel	Hi-Steel	50,000	70,000	22	0.12	0.75	0.15	0.95	0.18		0.55	
	Hi-Man	50,000	75,000	20	0.25	1.35	0.30	0.20				
	Hi-Man 440 (A440)	50,000	70,000		0.28	1.35	0.30	0.20				
	Tri-Steel	50,000	70,000	22	0.22	1.25	0.30	0.20				0.02 V
Jones & Laughlin	Jalten No. 1	50,000	70,000	22	0.15	1.30	0.10	0.30				0.05 V
	2	50,000	70,000	22	0.15	1.40	0.10	0.30				
	3	50,000	70,000	22	0.25	1.50	0.25	0.20				
	JLX-45-W	45,000	65,000	22	0.15	0.75	0.10					0.03 Cb
	-50-W	50,000	70,000	22	0.15	0.75	0.10					0.03 Cb
	-55-W	55,000	75,000	22	0.15	0.75	0.10					0.03 Cb
	-60-W	60,000	80,000	22	0.15	0.75	0.10					0.03 Cb
Kaiser Steel	Kaisaloy No. 1	50,000	70,000	23	0.20	1.25	0.60	0.35	0.15	0.25	0.60	V, Ti
	2	45,000	60,000	25	0.12	0.60	0.50	0.30	0.10	0.25	0.60	V, Ti
	3	58,000	83,000	15	0.30	1.50	0.35	0.35	0.10	0.25	0.40	V, Ti
	Structural High Strength	50,000	75,000	18	0.27	1.60	0.30	0.20				
Lukens Steel	Cor-Ten	50,000	70,000	22	0.12	0.35	0.50	0.40		0.80	0.65	
National Steel (Great Lakes Steel and Weirton Steel)	GLX-45-W	45,000	65,000	22	0.15	0.75	0.10					0.03 Cb
	GLX-50-W	50,000	70,000	22	0.15	0.75	0.10					0.03 Cb
	GLX-55-W	55,000	75,000	22	0.15	0.75	0.10					0.03 Cb
	GLX-60-W	60,000	80,000	22	0.15	0.75	0.10					0.03 Cb
	N-A-X High Tensile	50,000	70,000	22	0.15	0.75	0.75	0.25	0.20	0.55		0.10 Zr
	N-A-X High Manganese	50,000	70,000	22	0.25	1.35	0.30	0.20				
Republic Steel	Republic 50	50,000	70,000	22	0.15	0.75		0.65	0.10	0.30	0.75	
	Republic M	50,000	75,000	20	0.25	1.35	0.30	0.20				
US Steel	Cor-Ten	50,000	70,000	22	0.12	0.35	0.50	0.40		0.80	0.65	
	Ex-Ten-45	45,000			0.20	0.75	0.10					0.01 Cb
	Ex-Ten-50	50,000			0.25	0.75	0.10					0.01 Cb
	Man-Ten	50,000	75,000	20	0.25	1.35	0.30	0.20				
	Man-Ten (A440)	50,000	70,000		0.28	1.35	0.30	0.20				
	Par-Ten	45,000	62,000	28	0.12	0.75	0.10					0.04 V
	Tri-Ten	50,000	70,000	22	0.22	1.25	0.30	0.20				0.02 V
Youngstown Sheet & Tube	Yoloy	50,000	70,000	22	0.15	0.75	0.30	1.00			1.70	
	Yoloy A242	50,000	70,000	22	0.22	1.25	0.30	0.20				0.02 V
	Yoloy E HSX	45,000	80,000	25	0.18	1.00	0.30	0.35		0.40	0.70	
	Yoloy EHS	50,000	70,000	22	0.18	1.00	0.30	0.35	0.40	0.40	0.70	
	Yoloy M-A	50,000	70,000	20	0.25	1.60	0.30	0.35				
	Yoloy M-B	45,000	70,000	22	0.23	1.40	0.25	0.20				
	Yoloy 45W	45,000	65,000	30	0.15	0.65						Cb
	Yoloy 50W	50,000	70,000	28	0.15	0.65						Cb

Properties and composition of the CONSTRUCTIONAL ALLOY STEELS

Producer	Alloy	Yield Point, psi	Ult. Strength, psi	Elong., %	Nominal Composition, % C	Mn	Si	Cu	Mo	Cr	Ni	Other
Great Lakes Steel	N-A-Xtra 80	80,000	95,000	18	0.15	0.80	0.70		0.20	0.65		0.09 Zr
	90	90,000	105,000	18	0.15	0.80	0.70		0.20	0.65		0.09 Zr
	100	100,000	115,000	18	0.15	0.80	0.70		0.20	0.65		0.09 Zr
	110	110,000	125,000	18	0.15	0.80	0.70		0.20	0.65		0.09 Zr
Jones & Laughlin	Jalloy-S-90	90,000	105,000	18	0.15	1.25	0.25		0.25			
	Jalloy-S-100	100,000	115,000	18	0.15	1.25	0.25		0.25			Cb
	Jalloy-S-110	110,000	125,000	18	0.15	1.25	0.25		0.25			Cb
Lukens Steel	T-1	100,000	115,000	18	0.15	0.80	0.25	0.35	0.55	0.60	0.85	V, B
Republic Steel	Republic 65	65,000	85,000	20	0.15	1.00	0.15	1.15	0.25		1.25	
	70	70,000	90,000	18	0.20	1.00	0.15	1.25	0.25		1.50	
US Steel	T-1	100,000	115,000	18	0.15	0.80	0.25	0.35	0.55	0.60	0.85	V, B
Youngstown Sheet & Tube	Yoloy S	65,000	95,000	20	0.12	0.60	0.30	1.00			1.80	

Fillet welds in particular require better-than-average care to avoid undercuts and craters at the fillet toe (this place is a natural stress-raiser).

Corrosion resistance of the constructional alloy steels is generally at least 4 times that of carbon steel. The resistance comes from the dense, tight oxide that is formed.

Hardened further to 320 Brinell or higher, these steels gain better wear-resistance as well as improved mechanical properties. At these hardnesses, formability is lower but the steel will still retain adequate weldability and toughness for impact resistance.

Properties of high-strength alloy steels at 1000 F

Steel	1000-hr Rupture Strength, psi
Hot-work tool steel—Potomac M	83,000
Martensitic stainless steel—422M	60,000
Low-alloy steel—17-22AS	60,000
PH Austenitic stainless—A-286	87,000

	Load to produce % creep strain in 1000 hr, psi 0.1%	0.2%	0.5%	1.0%
Hot-work tool steel—Halmo	25	44	72	86
PH austenitic stainless—A-286	70	83	87	89

HIGH-STRENGTH ALLOY STEELS

The special alloys for the higher strength and elevated-temperature needs met mainly in aircraft applications are becoming more widely used—to take advantage of valuable properties not obtainable in other high-strength materials. In general, these special steels can be divided into 6 major groups, which are ranked here in decreasing order of strength.

1. Hot-work tool
2. Martensitic stainless
3. Hardenable low-alloy
4. Semi-austenitic stainless (precipitation-hardened)
5. Austenitic stainless (cold-rolled)
6. Austenitic stainless (precipitation-hardened)

The first three, all martensitic in structure, have the best ductility at ultrahigh strengths over 200,000 psi. However, they must be heat-treated after forming or welding. Dimensional changes during the hardening heat-treatment cause distortion unless the part is constrained by fixtures. After hardening, these martensitic steels are difficult to machine, and during the heat treating they decarburize unless protected by coatings or neutral atmospheres.

Hardenable low-alloy steels

These have ultimate strengths over 250,000 psi. Alloy content is low and they are cheapest of the ultrahigh-strength steels. They have more corrosion resistance than carbon steel but are poorest of the ultrahigh-strength steels.

SAE 4340 is a basic alloy in this category. Its 0.40% carbon content gives strengths of 260,000 to 280,000 psi but tends to be notch-sensitive at this strength level. Hardenability is low, so it must be oil-quenched for hardening. Strength falls off above 400 F because 4340 must be tempered below 450 F to avoid low-impact properties from the temper brittleness range (450 to 800 F). Forming and welding is done on annealed stock and then heat-treated for strength.

The new ultrahigh-strength steels in this category have better elevated-temperature properties, less notch sensitivity, and are processed easier because they are an air-hardening type. Their higher ductility makes them suitable for high-strength pressure vessels loaded under multiaxial stresses. Air hardening eliminates need for drastic quench-

Properties and composition of the HIGH-STRENGTH LOW ALLOY STEELS

Steel	0.2% Yield, psi	Ult. Strength, psi	Nominal Composition, % C	Mn	Si	Ni	Cr	Mo	V	Other
Martensitic low-alloy										
SAE 4130	225,000	250,000	0.30	0.50	0.30		0.95	0.20		
SAE 4340	to	to	0.40	0.65	0.30	1.80	0.80	0.25		
17-22AS (Timken)	260,000	300,000	0.30	0.50	0.65		1.25	0.50	0.25	
17-22AV (Timken)			0.28	0.75	0.65		1.25	0.50	0.85	
Hy-Tuf (Crucible)			0.25	1.30	1.50	1.80		0.40		
USS Strux (US Steel)			0.38	0.85	0.70	0.80	0.75	0.50	0.06	0.0015 B
Unimach UCX-2 (Universal Cyclops)			0.38	0.70	1.0		1.10	0.25	0.15	1.0 Co
300 M (INCO)			0.40	0.75	1.60	1.85	0.85	0.40	0.08	
Air Steel X-200 (US Steel)			0.43	0.85	1.50		2.00	0.50	0.05	
Martensitic stainless										
Type 418 Special (Allegheny Ludlum)	200,000	240,000	0.17	0.50	0.50	2.00	13.0	0.50		3.00 W
Type 422 (Crucible)	to	to	0.22	0.65	0.35	0.70	12.0	1.00	0.25	1.00 W
Type 422 M (Crucible)	210,000	265,000	0.28	0.85	0.25	0.20	12.0	2.25	0.50	1.70 W
12 Mo V (US Steel)			0.25	0.50	0.50	0.70	12.0	1.0	0.30	
Hot-work die										
Peerless 56 (Crucible)	250,000	300,000	0.40	0.55	1.00		3.25	2.80	0.35	
Potomac M (Allegheny Ludlum)	to	to	0.40	0.35	1.00		5.25	1.25	1.00	
Halmo (Crucible)	260,000	320,000	0.35	0.28	0.72		5.16	5.14	0.66	
Vasco Jet 1000 (Vanadium-Alloys)			0.40	0.30	0.90		5.00	1.30	0.45	
Unimach 1 (Universal Cyclops)			0.40	0.40	1.00		5.00	1.40	0.45	
Unimach 2 (Universal Cyclops)			0.50	0.40	1.00	1.50	5.00	1.40	1.00	
Potomac A (Allegheny Ludlum)			0.40	0.30	0.90		5.00	1.30	0.50	
Semi-austenitic stainless										
PH 15-7 Mo (Armco)	220,000	230,000	0.07	0.60	0.40	7.00	15.0	2.25		1.15 Al
17-7PH (Armco)	to	to	0.07	0.60	0.40	7.20	17.1			1.15 Al
AM-350 (Allegheny Ludlum)	300,000	310,000	0.10	0.90	0.40	4.20	17.0	2.75		0.10 N
17-4 Mo (Universal Cyclops)			0.10	0.90	0.40	4.20	17.0	2.75		0.10 N
AM-355 (Allegheny Ludlum)			0.13	0.95	0.50	4.35	15.5	2.75		0.10 N
Austenitic stainless—cold-rolled										
301	175,000	195,000	0.10	0.80	0.50	7.00	17.0			0.15 N
201	to	to	0.10	7.00	0.75	4.00	17.0			0.15 N
Tenelon (US Steel)	190,000	210,000	0.10	14.50	0.50		17.0			0.40 N
Austenitic stainless—precipitation-hardened										
HNM (Crucible)	100,000	150,000	0.30	3.50	0.50	9.5	18.5			
A-286 (Allegheny Ludlum & Universal Cyclops)	to 125,000	to 170,000	0.50	1.35	0.95	26.0	15.5	1.25	0.30	Al, Ti

ing of formed parts. This reduces but does not eliminate distortion from hardening. Air-cool hardening also ensures complete hardening through thick sections.

The steels like 17-22 AS, adapted from alloys developoped for high-temperature bolts, retain strength up to 1200 F but sacrifice room-temperature properties. They are noted for high creep strength.

Hot-work tool steels

These offer the highest strength-weight ratio between 400-1000 F. They are air-hardening, have good ductility from −100 F to 1000 F and their notched tensile strengths are higher than when they aren't notched. Higher Mo and V help them retain strength at elevated temperature.

These steels are generally used in three strength levels for specific applications.

- 290,000-psi tensile strength for maximum yield strength, with transverse ductility sufficient for large forged parts.
- 260,000-psi tensile for maximum fatigue strength and sufficient multiaxial properties for welded pressure vessels.
- 220,000 psi for strength stability above 1000 F and maximum ductility for severe notch applications.

Oxidation resistance is better than that of the low-alloy steels. Decarburization is retarded but not eliminated. Their chromium content, about 5%, is not sufficient to make these alloys completely stainless.

Hot-work steels are more difficult to weld than low-alloy steels like 4340, and both preheat and postheat are required. This is true for all steels than are air-hardenable.

Martensitic stainless steels

They have highest strength and lowest thermal expansion of the stainless steels. Oxidation and corrosion resistance are better than for hot-work steels but corrosion resistance may not be sufficient for outdoor exposure.

Strength properties are isotropic but below those of the hot-work steels at any temperature. However, they are good choices for brazing because they harden during furnace-cooling from brazing temperatures.

Heat treatment is critical—optimum combination of tensile strength and impact strength is in a narrow range and difficult to control. Also, treatments for best strength make them prone to stress corrosion.

Like the other martensitic alloys they are difficult to weld, hard to machine when heat-treated, susceptible to hydrogen embrittlement and decarburization.

Resistance-welding cycles are long with these steels—time for one weld is as long as 55 seconds because the spot must be tempered immediately with a post-heat weld current.

Semi-austenitic stainless steels

These are gaining wide use because they are corrosion-resistant, have high strengths and are easy to fabricate. However, they embrittle in the 600 to 800-F range.

These steels resist stress-corrosion cracking at high strengths because they remain partly austenitic after hardening. For example, AM 350 is resistant to stress corrosion at RC44 hardness. In contrast, Type 419 is susceptible to this type of cracking at RC36.

Ductile and easy to form when annealed, these steels are easy to harden because of two unusual characteristics. The suppressed quench-hardening starts at relatively low temperatures, and secondary hardening by aging further strengthens the material. Two optional heat-treat cycles are used. The aging treatment hardens by cooling from about 1400 F and aging at about 100 F. The refrigeration treatment sensitizes the steel at 1750 F, so transformation can be accomplished by refrigeration cooling from + 200 F to −100 F. The next step is to age the steel. With this cycle, close tolerances are easy and fixtures are cheap and simple to make. This treatment also gives higher strengths and better corrosion resistance, but requires an extra sensitizing step.

Precipitation-hardening austenitic steels

They have low tensile properties at room and intermediate temperatures, but compared with the martensitic steels their properties do not fall off as sharply in the 800 to 1200-F range. Stress-rupture strength and creep resistance at 1000 to 1200 F are better than with other high-strength steels. Ductility is superior—tensile elongation is 25% at room temperature. Corrosion resistance is high—equivalent to 304 (18 Cr – 8 Ni) and oxidation resistance is equivalent to that of type 310 (25 Cr – 20 Ni). They also contain the highest amounts of Cr and Ni, so are most expensive.

Cold-rolled stainless steels

Their advantages are very high strength with excellent corrosion resistance. But properties are directional from rolling and ductility is low. Limited to cold-worked sheet or strip, these steels are best adapted for applications that require little or no forming. Spot welds are a good way to fasten them. The weld nuggets are soft and ductile but stiffened by the cold-worked metal surrounding the spot. Elevated-temperature properties fall off as cold-worked strength is relieved but the properties are sufficient to make these stainless steels useful for many applications up to 800 to 900 F.

EDITOR'S NOTE: For more on design and work with hardenable high-strength steels, see:

Design Guide for Stainless Honeycomb Sandwich Panels, Dec 5 '60, p 67—Gives design basics, with emphasis on materials and details of construction.

Cryogenic Sizing Freezes Accuracy into Hardenable Stainless Steel, Feb 15 '60, p 61—A subzero refrigeration process that offers close tolerances at low cost for complex parts from the PH semi-austenitic steels.

How to Estimate Cost of Hi-temp Alloy Parts, Feb 1 '60, p 58 — Chart guide compares manufacturing and processing costs to produce complex parts from high-strength materials suitable for high-temperature service.

The Best Spring Material for High Temperatures, Jan 18 '60, p 44—High strength can be secondary to stability when designing hi-temp springs.

7 Closer Looks at Metal Properties, Oct 25 '59, p 48—Hidden mechanical properties that can be found right in the test data help solve tricky design problems.

A Fresh Look at Leaded Steels, Apr 14 '58, p 72—Controlled additions of lead give high-strength steels good machinability without loss of tensile, impact and fatigue strengths.

High-temperature Stainless, Apr '57, p 135—Mechanical properties, structural stability and fabrication characteristics of five austenitic and three martensitic steels.

Fabricating Ultrahigh-strength Steel, Dec '55, p 170—How to work SAE 4340 for maximum strength and reliability; gives design tips and checklist to evaluate applications.

Ultrahigh-strength Steel for Aircraft Structures, Oct '53, p 129—Gives comprehensive design properties for SAE 4340.

How to Get Stronger Parts from Work-hardened Sheetmetal, Oct 26 '59—Shows how to process the material to take advantage of its outstanding advantages.

For a Stronger Metal Surface, Nov 14 '60, p 70—Compares different methods of boosting wear-resistance and fatigue strength.

Allowable Stresses in Flash-welded Joints, Oct 31 '60, p 39—Method correlates strength with magnetic flux.

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MAXIMUM STRESS IN CYLINDRICAL SHORT BLOCKS

Whether the block can stand both tension and compression, or only one—and regardless of the location of the load—here are the equations you need to fix max stress.

S WARREN KAYE
Missile Systems Div
Raytheon Co, Bedford, Mass

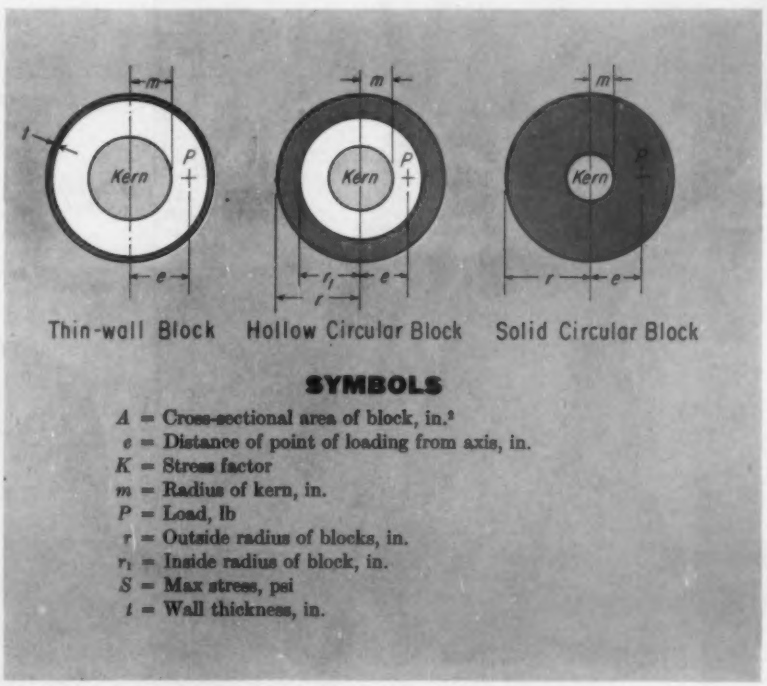
If a cylindrical short block can stand both compressive and tensile stresses, and is short enough to make bending negligible, finding the maximum stress caused by axial loads is easy. Just use this equation:

$$S = P/A(1 + 4e/r)$$

But masonry blocks can stand only compression, and thin-wall blocks can stand only tension. For these, two alternatives are possible—depending on where the load is applied. If it bears on a central area known as the kern, the simple equation above still applies. But if the load bears outside the kern, use the charts and equations on p 65 to find the solution. Dimensions of the kern vary with the type of block; equations are included for its radius for each of the three types of short cylindrical blocks—thin-wall, hollow and solid.

In blocks that can stand both tensile and compressive stresses, there is a reversal of stresses when the load is applied sufficiently far from the center. When the load is applied outside the kern, the bending stresses become large enough to locate compressive stress on one side of the block, but tensile stress on the other.

If the block cannot withstand a second type of stress, this reversal cannot occur. Only part of the cross-section is under stress; the farther off-center the load, the smaller the load-carrying section. The result is that this single stress rises to a higher maximum than it would if the block could withstand two types of stress.



SYMBOLS

A = Cross-sectional area of block, in.²
e = Distance of point of loading from axis, in.
K = Stress factor
m = Radius of kern, in.
P = Load, lb
r = Outside radius of blocks, in.
r_1 = Inside radius of block, in.
S = Max stress, psi
t = Wall thickness, in.

Finding maximum stress in such cases has been simplified in the set of equations by adding a stress factor K, which can be found from the charts. This factor varies from 2 to infinity as the point of loading moves from m to the outside edge.

continued, p. 65

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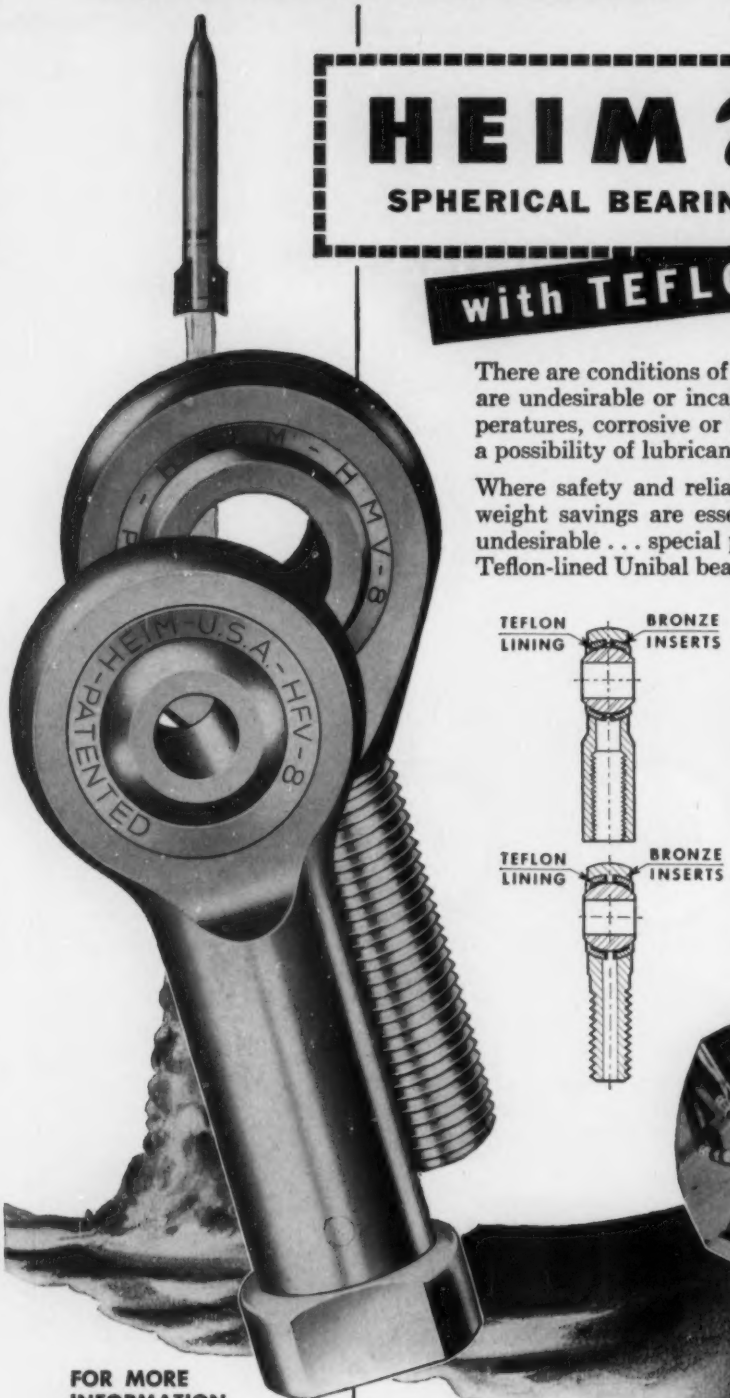
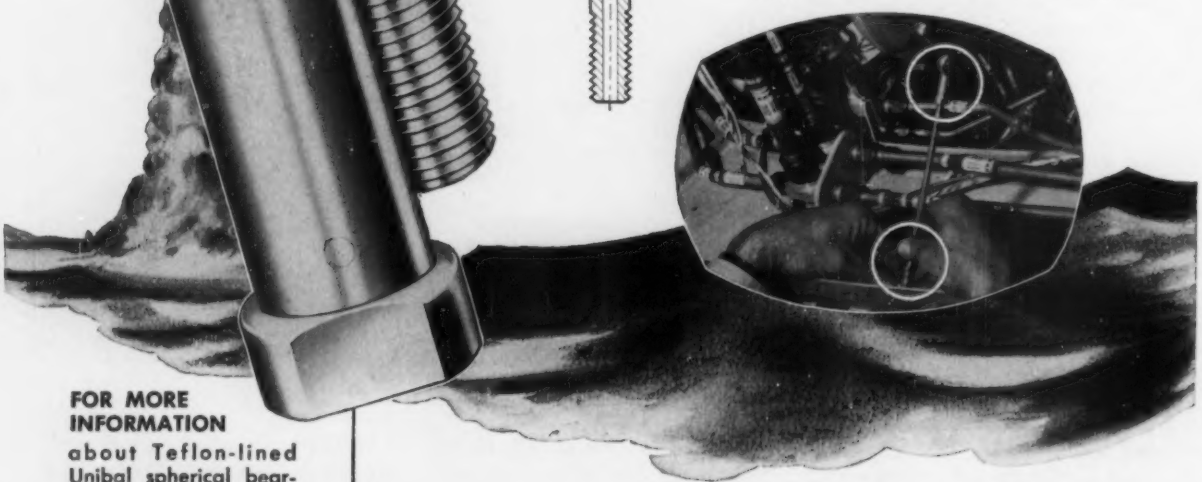


Aircraft and missile manufacturers find that these fiber-lined Unibal bearings, especially for rod ends in rotor assemblies of helicopters, as well as in most other linkages, are outstanding in their performance and durability. They require no lubrication, and after hundreds of hours of service are still in perfect condition.

The Unibal Spherical Bearing Rod End corrects misalignment in all directions, has high load ratings, is light in weight, occupies minimum space, and is extremely simple to assemble as part of a linkage.



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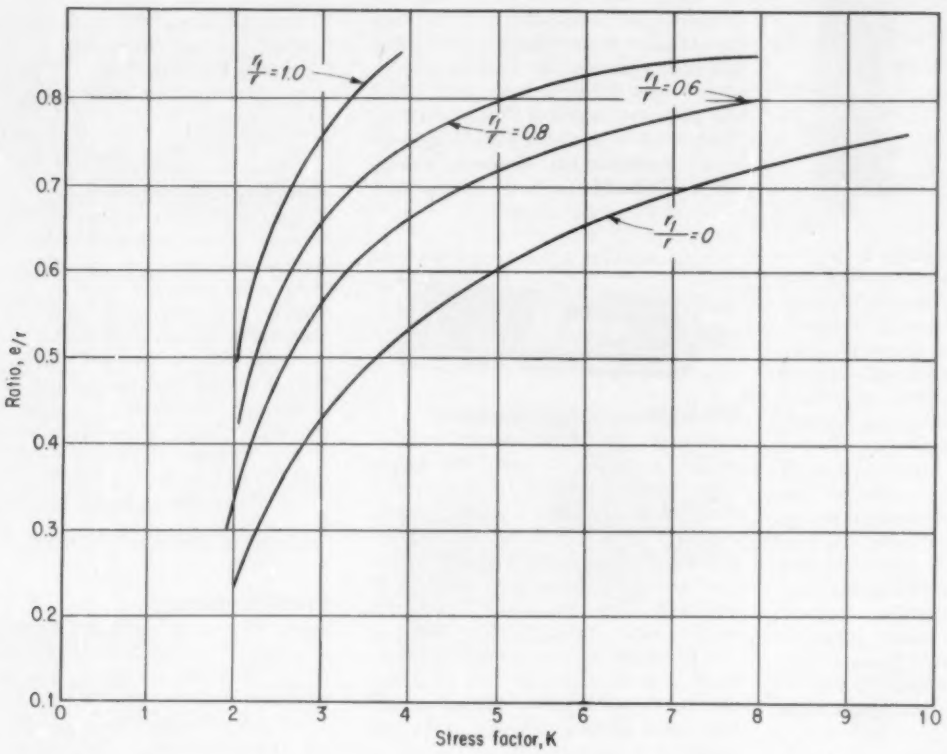
CYLINDRICAL SHORT BLOCKS continued



EQUATIONS

Thin-wall Shell

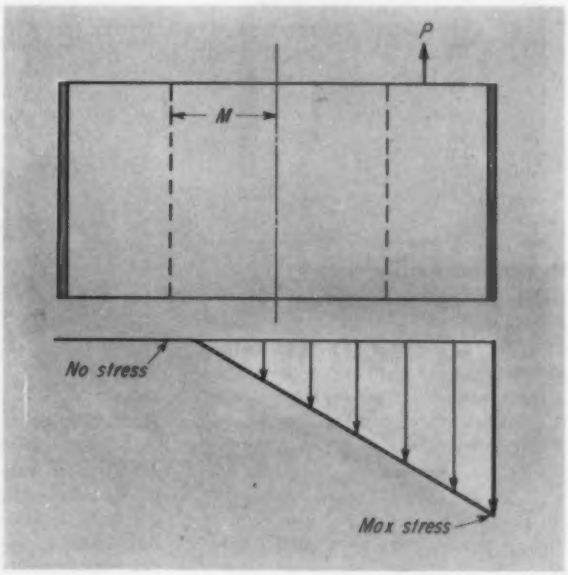
(r_1/r is almost 1.0)
Max stress $S = PK/tr$
Kern radius $m = r/2$

Hollow Circular Section

Max stress $S = PK/A$
Kern radius $m = (r^2 + r_1^2)/4r$

Solid Circular Section

Max stress $S = PK/A$
Kern radius $m = r/4$



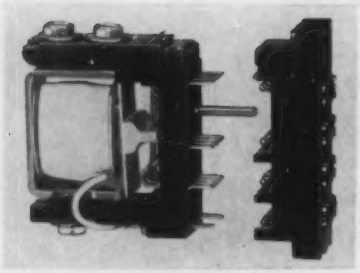
EXAMPLE:

A 1000-lb load pulls 2 in. from the center of a 6-in.-dia metal tube with a 1/8-in. wall thickness. What is max stress?

SOLUTION:

Since $r_1/r = 2\frac{1}{4} \div 3 = 0.96$, or approximately 1.0, consider this a thin-wall tube; $m = r/2 = 1.5$, so load bears outside kern.
Ratio $e/r = 2/3 = 0.67$. From curve find stress factor $K = 2.48$.
Max stress $S = PK/tr = 10^3 \times 2.48/0.125 \times 3 = 6610$ psi.

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



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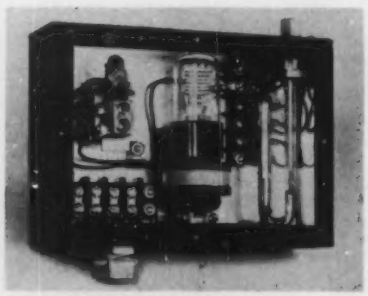
"directs" or sets up circuits in applications that do not require making or breaking a particular circuit. Primarily designed for logic or arithmetic section of computers and business machines, unit is said to last for 200 million operations. Contacts are 4PDT, consisting of two silver alloy wires per pole, and are rated at 3 amps (carry only). Operating time is 5.5 millisec including bounce. Coils are rated at 20 to 115 v dc, using a max 4-w power. Ambient temperature is stated at 122 F. Relay measures 2¼ x ⅝ x 2 in. and weighs approx 1¾ oz. Priced at less than $4 each in production quantities; delivery in approx. 4 to 6 wk. Smaller quantities delivered as required. **RBM Controls Div, Essex Wire Corp, Logansport, Ind.**

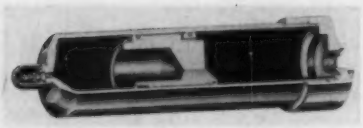
Circle 300 on Reader Service Card



Manometer eliminates lubricant contamination . . .

of control-switch contacts in vacuum-actuated switch. Four separate fixed-control contacts and a common return contact are enclosed within U-tube manometer partially filled with mercury. When pressure falls, indicating better vacuum, mercury column on manometer's closed or left-hand leg also falls, exposing contacts and initiating control action. When pressure rises, reverse action takes place. Each fixed control contact can be set at any level at intervals of 5, 10, 15 and 25 mm Hg. Switch controls start and stop action at any vacuum level within 1 to 300 mm Hg. Includes 15-sec, SPDT, 110-v, 60-c time-delay relay with 10-amp contact rating. Input voltage is 115 v, 60 c, while max controlled current is 10 amp at 115 v, 5 amp at 220 v. Priced at $105; delivery in 3 wk. **Fredericks Co, Bethayres, Penna.**

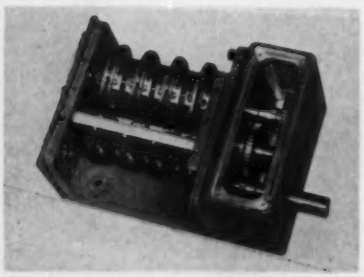
Circle 301 on Reader Service Card



Oil-hydraulic accumulator . . .

operates as (1) a power storage chamber so that a low-volume pump can supply brief, but intense energy; (2) as a pressure compensator to maintain system pressure and allow holding cylinders to maintain grip; and (3) to eliminate surges and vibration, smooth out pressure pulses and prevent shock from fast-closing valves. Has weldless steel, one-piece outer shell and statically-balanced aluminum piston. Available in six models for 3000-psi service and in four models for 3500-psi service. Stock sizes range from 1 pt to 2½ gal. overall. Oil volume is 29 to 230 cu in. for 3000-psi models; 230 to 575 cu in. for others. Overall size is 3 to 5½-in. dia, 11 to 39 in. long. Port size is ¼ to 1¼ in. **Crescent Hydraulic Co. 1303 Otsego Rd, Allegan, Mich.**

Circle 302 on Reader Service Card



Rotating cam limit-switch . . .

has 10 gear ratios ranging from 2:1 to 400:1. Gear reducer with ¾-in. shaft extension and keyway adds 3 in. to over-all length of standard 1:1 switch. Available with from 1 to 24 circuits. Adjustable cam lobe provides adjustment range from 8 to 360°. Rated at 5 amp, 600 v ac; 6 amp, 440 v ac; 10 amp, 220 v ac; and 15 amp, 115 v ac. SPDT construction is standard. **Gemco Electric Co, 25685 W Eight Mile Rd, Detroit 40.**

Circle 303 on Reader Service Card

Recentering mechanism . . .

returns shaft of components such as synchros, potentiometers, encoders, commutator switches, gear trains, etc. to center. Has adjustable stops up to 320° rotation and meets MIL specifications. Available in sleeve or ball-bearing design. One type comes in standard synchro sizes 5, 8, 11 and 18. Another type is furnished in two sizes for inclusion in other types of control systems. Prices range from $40 to $80. Delivery in 30 days. **MagneTec Corp, 7232 Eton Ave, Canoga Park, Calif.**

Circle 304 on Reader Service Card

Flexible plastic . . .

carries solvents in liquid and vapor form at up to 175 F. Said to resist same powerful solvent vapors (including fuels, bases, aromatics, alcohols, etc.) as more costly rigids and stiff semirigids. Though swelling may result when handling organic solvents, the material reportedly retains its strength and impermeability. In special form, it can resist most ketones. Makes possible lightweight flexible reinforced ducting and tubing in dia from 1 to 4 in. and in a variety of lengths. Low pressure hose can be supplied in both compressible and stretchable forms. **Dayton Dayflex Plastics Co, Div Dayco Corp, Dayton, Ohio.**

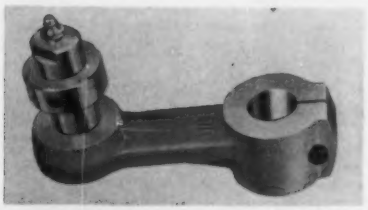
Circle 305 on Reader Service Card

Portable vibration analyzer . . .

provides two different signal-analysis modes —direct reading and deviation monitor— making it suitable for laboratory use or for incorporating into industrial machinery and other heavy equipment. Operates on internal battery or on standard 110 v ac. Voltage inputs, which are manually selected, can be varied from 50 microv to 110 v—permitting amplitude range from 5 microin. to $\frac{1}{16}$ in., peak to peak; frequency range from 5 to 10,000 cps and from 300 to 100,000 cpm; and velocity range from 50 microin. per sec to 100 in.

per sec. Accuracy of ranges is ±2%. Has continuously variable frequency filter system to allow close investigation of discreet frequencies and associated amplitudes within complete spectrum. Integral strobe light freezes motion for slow-motion studies. Has complete transistor-equipped circuitry and is priced below $2000. Delivery in 30 days. **Raydata Corp, 1078 E Granville Rd, Worthington, Ohio.**

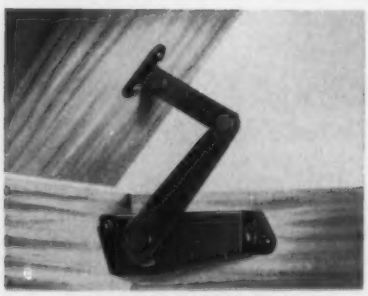
Circle 306 on Reader Service Card



Shaft-mounted drive tensioner . . .

has arm which can be rotated and locked in any position on a 360° arc. A 2-in.-long interchangeable shaft is supplied with each tensioner, while 3- or 4-in.-long shafts are available for multiple width drives. Bronzed bushed sprocket and pulley idlers come in 14 sizes. Priced at $12. **Brewer Machine & Gear Co, 1441 N 2nd St, St Louis.**

Circle 307 on Reader Service Card



Center-balancing lid support

allows full 90° lid opening. Mounted on surface, it requires no mortising. Front-mounted tension screw provides easy adjustment. Available with tension springs for light, medium or heavy lids. Made of brass with lacquer coating and bronze finish for right- or left-hand applications. **National Lock Co, Rockford, Ill.**

Circle 308 on Reader Service Card

Seamless brass tubing . . .

has 0.050 to 0.500-in. OD, 0.005 to 0.030-in. walls and ¼-in. to 15-ft lengths. Tolerances are said to be as narrow as ¼ of ASTM B251 values. Shapes include round, elliptical, teardrop, polygonal and polygonal outside and round inside. Delivery on West German-made product in 2 to 6 wk, depending upon specifications. **Avins Industrial Products Corp, 50 Broadway, New York 4.**

Circle 309 on Reader Service Card

Fluxless solder for aluminum

and other nonferrous metals is a zinc-lead-tin alloy homogenized below its molecular level. Can penetrate surface oxides and fuse with aluminum, copper, brass, zinc or potmetal and with steel or iron surfaces which have been galvanized, coppercoated or tinned with soft solder. Capillary action while molten permits use on thin-gage aluminum without melt-through. Electrically balanced homogeneous composition reportedly curbs corrosion due to galvanic action. Available in 500, 600 and 800 F versions. Prices range from $1.95 for 1 lb to $475 for 500 lb. **Chem-alloy Electronics Corp, Gillespie Airport, Santee, Calif.**

Circle 310 on Reader Service Card

Three-figure magnetic counter

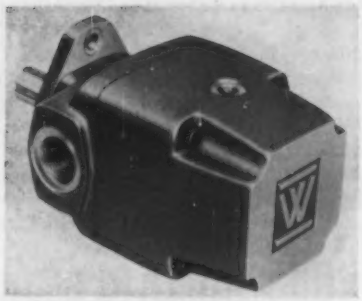
has small light in cover to illuminate counter-wheels. Records up to 20 pulses per sec. Available in either add or subtract versions and for 6, 12, 24 and 110 v dc operation. Said to last for a min 1 million counts in temperatures of from −65 to 160 F; vibration of 5 to 55 cps, 0.036 in. DA or 55 to 300 cps, 10 g; and shock of 6 g. **Abrams Instrument Corp, 606 E Shiawassee St, Lansing 1, Mich.**

Circle 311 on Reader Service Card

Welded tubing . . .

is cold-drawn over mandrel and said to cost from 5 to 45% less than cold-finished seamless tubing while offering closer tolerances, concentricity, improved surface finish and better subsurface characteristics. Tubing begins with sheet mill product rather than tube round. Welding flash on both inside and outside is removed to close tolerances during manufacture, while heat treatment in controlled-atmosphere furnace stress-relieves weld area before cold finishing. From stock in variety of sizes. **Jones & Laughlin Steel Corp, 3 Gateway Center, Pittsburgh 30.**

Circle 312 on Reader Service Card



Piston motors and pumps . . .

in four different capacities, have displacements of 0.72, 1.09, 1.45 and 1.81 cu in. per revolution. Rated for continuous 3000-psi duty and intermittent pressures to 3500 psi. Capacities are from 3.3 to 8.5 gpm at 1200 rpm and 5 to 14 gpm at 1800 rpm. Operating speeds are up to 2400 rpm, at which the largest unit can deliver 18 gpm. Used as motors, units have theoretical torque ranges of 11.52, 17.28, 23.04 and 28.80 in.-lb per 100 psi; output hp ranging from 5.5 to 14 at 1200 rpm and from 8 to 22 at 1800 rpm, operating at 3000 psi. Largest size running at 2400 rpm delivers 28 hp at 3000 psi. Pumping unit can be removed and serviced without disturbing piping setup, while entire unit can be disassembled and rotation reversed in the field. Mounting bosses handle 1-in. NPT inlet or 1¼-in. OD tubing thread. **Webster Electric Co, Racine, Wis.**

Circle 313 on Reader Service Card

Vaporized-aluminum coating . . .

laid over face of silicone rubber-coated glass cloth, protects equipment and personnel from high radiated heat. Reflects more than 90% of infrared rays generated by a thermal source and absorbs much of remaining heat. Two of the fabrics, available with plain silicone rubber coated side either cured or uncured, are suitable for continuous ambient temperatures from −100 to 500 F and for short periods at 700 F. They measure 0.008 and 0.014 in. in caliper and weigh 10 and 14 oz per sq yd. A third fabric withstands exposure to black body temperatures up to 6000 F. Tests indicate no thermal transmittance or discoloration of aluminum surface under 24 btu/ft²/sec input for 10 sec. **Irvington Div, Dept WO-502, Minnesota Mining & Mfg Co, 900 Bush Ave, St Paul 6.**

Circle 314 on Reader Service Card

Hinged-lever actuator . . .

on snap-action switch offers low operating force. Case-pivoted actuator arm has roller, straight lever, and is available with length and form variations for cam, roller or straight-line actuation. Switch is

continued on page 68

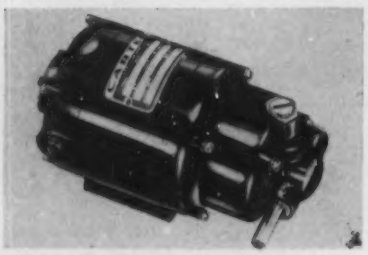
furnished in NO, NC, SPST or SPDT models. Has 0.187-in. overtravel with standard lever. Rated at 15 amp, 125/250 v ac; ¾ hp, 125 v ac; and 1½ hp, 250 v ac. Priced at 32¢ in quantities of 10,000. **Cherry Electrical Products Corp. W Deerfield Rd, Highland Park, Ill.**

Circle 315 on Reader Service Card

Watertight indicator light . . .

has silicone rubber boot with panel sealing rib to protect lens. Available with 6-, 14- or 28-v lamps, which can be replaced from front of panel, and anodized aluminum case. Lens come in seven colors. **Control Switch Div, Controls Company of America, Folcroft, Penna.**

Circle 316 on Reader Service Card



Fractional-hp gearmotors . . .

have phenolic gears said to provide quiet operation and cool running. Available in 20 single and double reduction models with shaft outputs ranging from 10 to 750 rpm. Shaft position can be changed to six 30° positions, using six screws. Inputs are from 12 to 220 v on most universal or series models. Shunt models are up to 115 v dc. Measures 6 x 3 7/16 x 3⅜ in. and weighs approx 5 lb. **Carter Motor Co, 2700 W George St, Chicago, 18.**

Circle 317 on Reader Service Card

Fractional-hp motors . . .

are said to weigh ½ less than comparable units. Rolled steel frames have cast aluminum alloy end shields. Available ratings are 1/20, 1/12, ⅛, ¼, ⅓, ½, ¾ and 1 hp. Capacitor-start, split-phase and polyphase units are made in frame sizes 48 and 56; repulsion-start, induction-run models come in frame size 56. **Master Electric Div, Reliance Electric & Engineering Co, 24701 Euclid Ave, Cleveland 17.**

Circle 318 on Reader Service Card

Vibration-resistant thermostat

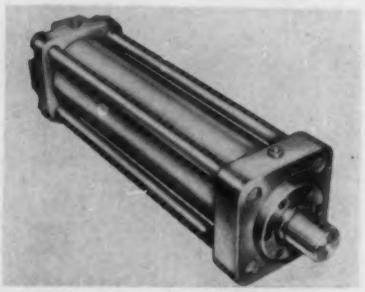
originally designed for aircooled engines shuts off magneto at head temperatures of 400 to 520 F. Switch, built into head bolt, is SPST, normally open or closed unit. Temperature setting range is −65 to 520 F. **Therm-O-Stats Inc, Chartley, Mass.**

Circle 319 on Reader Service Card

Cadmium sulfide photocell . . .

said to be suitable for applications where either a gas phototube or photomultiplier tube has been used, has resistance of over 1 megohm in darkness and broad response to visible light. Cadmium sulfide layer is vacuum-deposited over gold comb-like electrodes, permanently bonded to hard glass disk measuring 0.750 in. dia. Variations in light intensity reaching sensitive layer causes changing resistance. This alternates current flow and allows cell to act as light-activated switch. Is nonpolar and can be used on ac or dc. Power dissipation rating is ½ w continuous, 2 w for 1 min. Max voltage is 500 dc or 350 (RMS) ac. **JEM Electronics Div, Pioneer Electric & Research Corp, Forest Park, Ill.**

Circle 320 on Reader Service Card



10,000-psi double-acting cylinders . . .

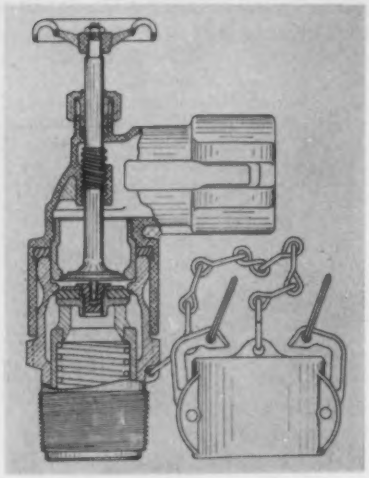
in capacities of 50, 75, 100 and 150 tons, have bore sizes of 3¾, 4½, 5⅛ and 6⅜ in. Built for both pushing and pulling operation. Have heat-treated alloy steel piston rods, tie-rods and nuts. **Precision Hydraulics Div, Owatonna Tool Co, 727 Cedar St, Owatonna, Minn.**

Circle 321 on Reader Service Card

Standard hardened ways . . .

are from stock at cost probably lower than that involved in making own sections. Available in 12 cross-sections and in over 80 sizes. Sections include flat and vee ways, composite die sections, heel and guide blocks and bronze wear plates. Provided in lengths up to 168 in. **Ohio Knife Co, Dept B, Cincinnati 23.**

Circle 322 on Reader Service Card



Dry-break quick coupler . . .

originally developed for collapsible military rubber tanks, are suitable for applications where frequent coupling and uncoupling is encountered. Consists of 2 x 1½-in. elbow valve assembly and 2-in. adaptor equipped with dry-break poppet. Poppet automatically closes to prevent accidental loss of product. Operates at pressures to 125 psi and temperatures to 225 F. From stock at $73.75 to $84.05. **OPW-Jordan Corp, 6013 Wiehe Rd, Cincinnati 13.**

Circle 323 on Reader Service Card

Etched printed part . . .

can be produced with kit in 7 min. Process handles up to 7000 parts per day, including nameplates, instrument dials and panels, schematics, serial numbers, labels, security badges, scales tool checks, etched photos, templets, etc. Requires no skilled labor or darkroom facilities. **Miller Dial & Nameplate Co, El Monte, Calif.**

Circle 324 on Reader Service Card

Transistor-regulated power supplies . . .

operate at any ambient temperature from 32 to 149 F. One model weighs 1 lb, handles 115-v, 400-cps input voltage and delivers 20 v dc, continuously adjustable over 10% range with external potentiometer. Rated output current is 50 ma at full load. Ripple is less than 2 mv (RMS), while regulation is greater than 0.1% from full to 50% of load. Uses silicon semiconductors and is suitable as either negative or positive supply. Another model weighs 4 lb and delivers 250 v dc with an output current of 250 ma. Ripple

continued on page 73

HANDY ALLOY DATA SHEET

HANDY & HARMAN ENGINEERING DEPARTMENT
82 FULTON STREET, NEW YORK 38, N.Y.

TEC and TEC-Z

...How to choose between a soft solder and a brazing alloy

Handy & Harman provides *two* alloys that fit between "something stronger than the average soft solder but not as strong as a silver-brazing alloy." They are named TEC and TEC-Z and their flow points are intermediate between soft solders and silver-brazing alloys. Joints made by these alloys are strong in straight tension or shear. For instance, butt joints of cold-worked copper can be made having a tensile strength of about 25,000 psi. This is approximately 10,000 psi. more than can be obtained with tin-lead soft solders. TEC joints retain their strength at elevated temperatures much better than the tin-lead soft solders. As shown in the table below, the strength of the solder itself at 425° F is about the same as a 50% tin–50% lead solder at room temperature in short-time tensile tests.

Applications—One example is a thermostatic bellows where the operating temperature is too high for soft solders (tin-lead), yet requires a joining medium which will not anneal the bellows. Another use is gun parts which require joint strength at higher than soft-solder operating temperatures *plus* corrosion resistance to solutions used in cleaning and blackening. Also for lamp bulb bases operating at approximately 350°-500° F. Automotive applications and heat exchangers. TEC conforms to Government Specifications Mil-S-19234 (Nord); both TEC and TEC-Z are available in sheet, wire, powder, and preforms to specifications.

NOMINAL COMPOSITIONS

	TEC	TEC-Z
Silver	5% plus or minus 0.5%	5% plus or minus 0.5%
Zinc		16.6% plus or minus 0.5%
Cadmium	95% plus or minus 0.5%	78.4% plus or minus 0.5%

PHYSICAL PROPERTIES

	TEC	TEC-Z
Color	White	White
Melting Point	640° F	480° F
Flow Point	740° F	600° F
Density (Troy oz/cu in.)	4.60	4.53
Electrical Conductivity (Cu=100)	22.0%	20.6%
Electrical Resistivity (Microhm-cm)	7.9	8.4

STRENGTH COMPARISON TEC vs. Pb-SN

	TENSILE STRENGTH LBS/SQ IN.	TENSILE STRENGTH LBS/SQ IN.
	TEC	Pb-SN
ROOM	16,400	2,500
300° F	4,400	650
425° F	2,600	Melts
500° F	1,700	

The information and data on this page are available in our Handy Alloy Data Sheet. Ask for "TEC." Handy & Harman, 82 Fulton Street, N.Y.C. 38.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

Offices and Plants: Bridgeport, Conn. • Chicago, Ill. • Cleveland, Ohio • Dallas, Texas • Detroit, Mich. • Los Angeles, Calif. • New York, N.Y. Providence, R. I.. • Montreal, Canada • Toronto, Canada

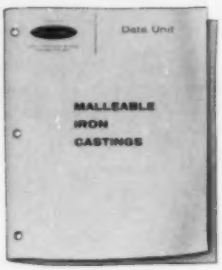
DISTRIBUTORS IN PRINCIPAL CITIES

New Cars and Trucks Use More Malleable For Better Performance...Lower Cost

As the automotive industry steps up its drive to pack greater performance into lighter weight vehicles and still hold costs in line, the demand for Malleable iron castings continues to increase. Noted for their strength, toughness, machinability and economy, Malleables are used as key components in every make and type of vehicle.

Matching each new advance in automotive technology, Malleable is now available in a broad range of properties, including tensile strengths from 50,000 to 120,000 psi!

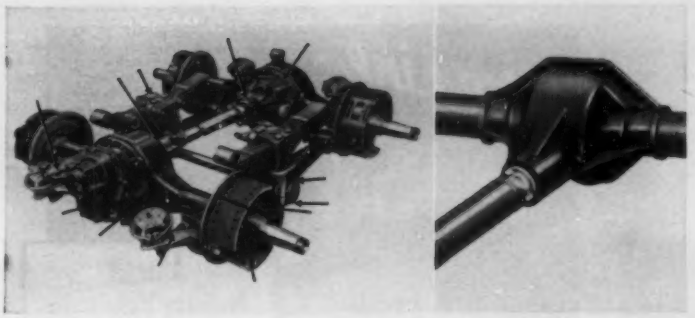
Find out now how much Malleable castings can improve your products. Contact any company that displays this symbol —



For Free Literature on advantages of Malleable iron castings, with examples from the automotive industry, ask any member company for Data Unit No. 113, or write to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

MEMBER
MALLEABLE
CASTINGS COUNCIL

Testifying to Malleable's outstanding ability, pearlitic Malleable iron crankshafts are now used in both cars and trucks, like this new heavy-duty highway hauler. Pearlitic Malleable was chosen for its high strength, wear resistance, damping capacity and machinability . . . Malleable is the most machinable of all ferrous metals of similar properties.



From the smallest cars to the largest trucks, all American vehicles rely on Malleable for a range of uses. In this tandem axle, for example, a total of 36 parts is Malleable.

Malleable differential carriers form the backbone of the rear axles on many new compact cars, as shown at the right above. Tubular steel extensions are pressed into the Malleable housing where they are "puddle" welded. Decisive factors in Malleable's selection were strength, economy, ease of machining and ability to be produced in a design that required a minimum of tooling expense.

The increasing conversion from other materials to Malleable castings for all kinds of parts from crankshafts to door hinges is adding momentum to the automotive industry's steadily increasing use of Malleable.

Among the many Malleable iron castings in this composite car are torsion bar arms and brackets, rocker arms, fan pulleys, sprockets, emergency brake drums, pedals and spiders, steering gear housings, universal joint yokes, bearing caps, transmission gears, shifter forks, turbine hubs and a variety of brackets, housings and cases.

For Quality and Economy Use

MALLEABLE

For Service Contact...

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Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Iron Works, Moline
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
National Mall. and Steel Castings Co., Cleveland 6

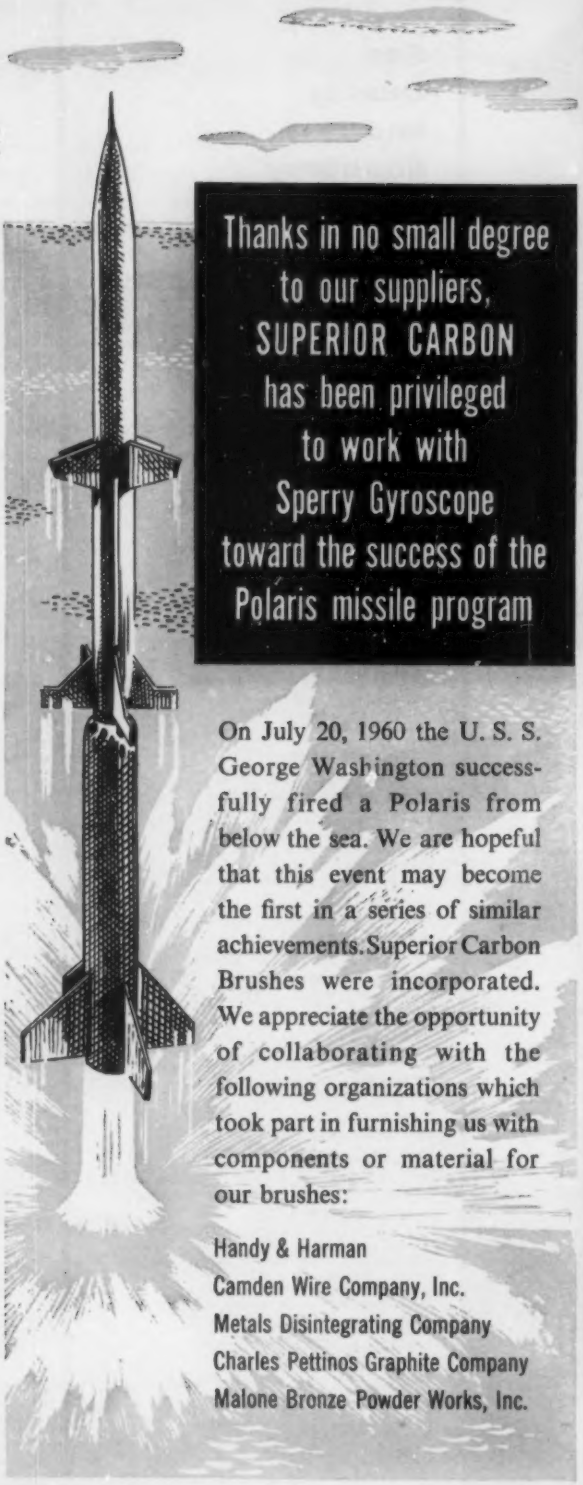
PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

These companies are members of the Malleable Castings Council



Thanks in no small degree to our suppliers, SUPERIOR CARBON has been privileged to work with Sperry Gyroscope toward the success of the Polaris missile program

On July 20, 1960 the U. S. S. George Washington successfully fired a Polaris from below the sea. We are hopeful that this event may become the first in a series of similar achievements. Superior Carbon Brushes were incorporated. We appreciate the opportunity of collaborating with the following organizations which took part in furnishing us with components or material for our brushes:

Handy & Harman
Camden Wire Company, Inc.
Metals Disintegrating Company
Charles Pettinos Graphite Company
Malone Bronze Powder Works, Inc.

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9115 GEORGE AVENUE • CLEVELAND 5, OHIO

BRUSHES • CONTACTS • SLIP RING ASSEMBLIES
POWDER METAL PARTS • MECHANICAL CARBONS

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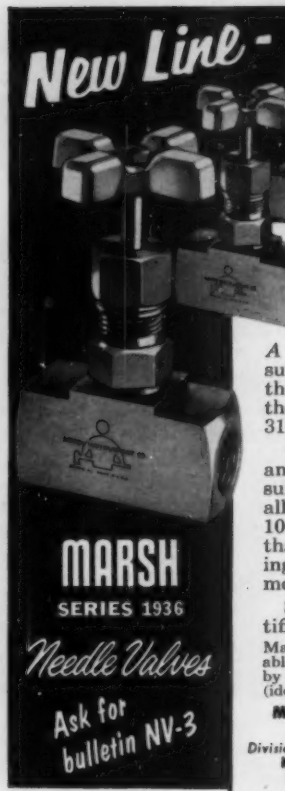


Marsh Needle Valves in 316 STAINLESS

A great combination: all the superlative construction of the Marsh Needle Valve with the corrosion-resistance of 316 stainless steel!

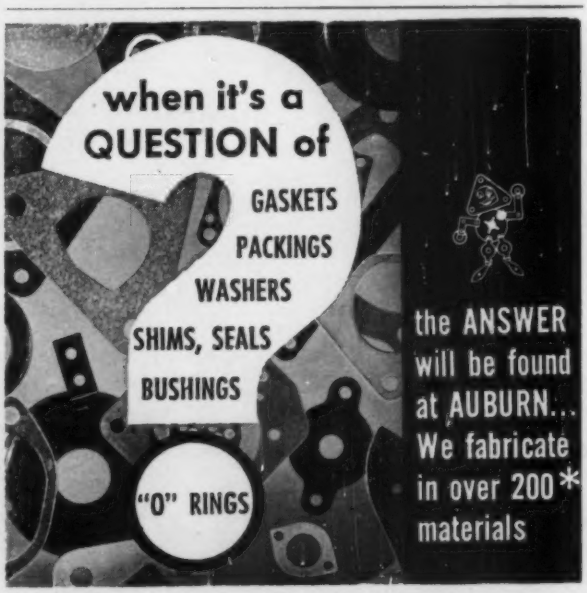
Gives precision throttling and tight closure on all pressures up to 6000 psi. Handles all temperatures from minus 100° F. to plus 500° F., thanks to "Marpak" packing system utilizing precision moulded Teflon.

Sizes ⅛" through 1". Identified by blue handle.

Marsh Needle Valves are also available in 416 stainless steel (identified by green handles) and in alloy steel (identified by yellow handles.)

MARSH INSTRUMENT COMPANY
Dept. 39, Skokie, Illinois
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada
Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

CIRCLE 204 ON READER SERVICE CARD



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is less than 15 mv (RMS) and regulation, better than 0.4% from full to half load and over range of 20% line voltage change. Both from stock. **Hycon Mfg Co, 1030 S Arroyo Pkwy, Pasadena, Calif.**

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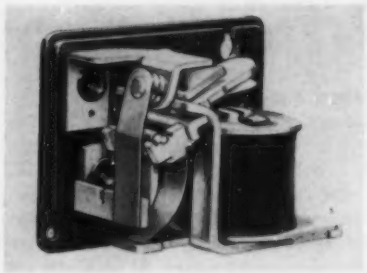


Voltage starting relay . . .

for capacitor-start motors up to 5 hp, is an electromagnetic switch which opens and closes its contacts according to voltage magnitude applied to relay coil. Normally closed contacts stay closed until motor builds up speed and start-winding voltage increases. Magnetic force then pulls in armature to core which opens contacts. Airgap construction is said to eliminate "residual magnetism" between armature and coil after relay is deenergized. **Ranco Inc, 601 W 5th Ave, Columbus 1, Ohio.**

Circle 326 on Reader Service Card

Vacuum pumps . . .

are fitted with ¼-, ⅓- and ½-hp motors and deliver 2.5, 5.0 and 9.0 cfm, respectively. Rotor slot device permits longer vanes, which can be removed for service without disturbing pump piping or motor mounting. Four vanes, sliding freely, hug inside periphery of pump housing. **Perfection Mfg Corp, 234 S 8th St, Delavan, Wis.**

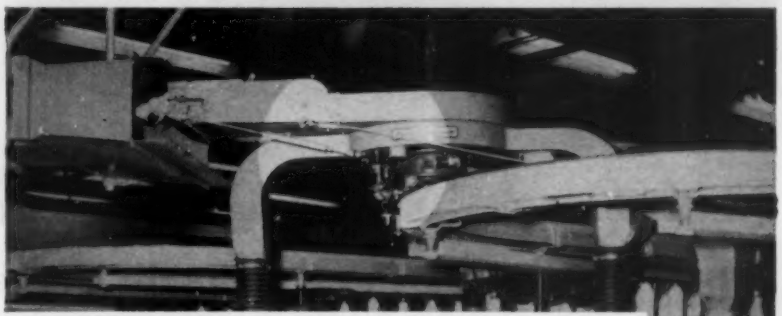
Circle 327 on Reader Service Card

Motor with 24 slot stators . . .

is suitable for applications where quietness and smooth actuation is important, such as office machines. Number of machine-wound stators is increased by eight on this 3-in. induction unit. Die-cast end parts are press-fit into frame for a reportedly accurate bearing alignment and uni-

continued on page 74

A clean sweep with APEX COVERED Universal Joints

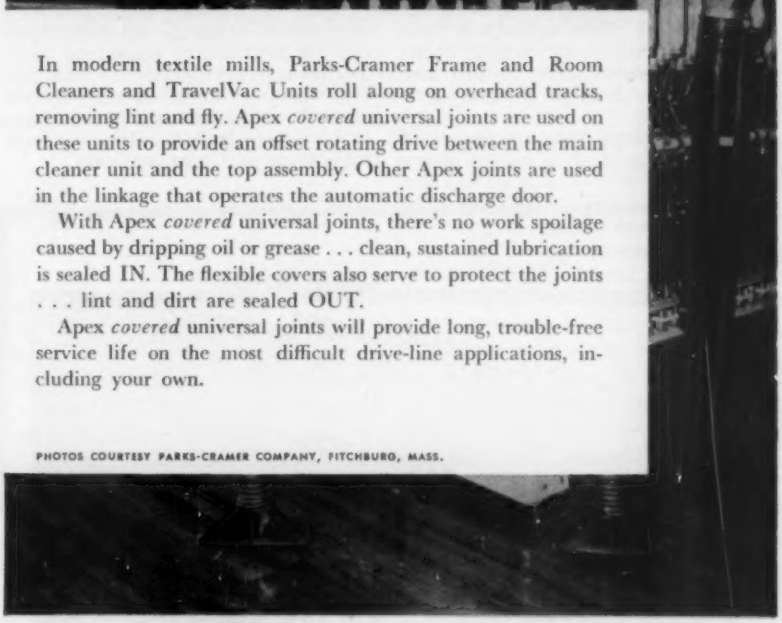


In modern textile mills, Parks-Cramer Frame and Room Cleaners and TravelVac Units roll along on overhead tracks, removing lint and fly. Apex *covered* universal joints are used on these units to provide an offset rotating drive between the main cleaner unit and the top assembly. Other Apex joints are used in the linkage that operates the automatic discharge door.

With Apex *covered* universal joints, there's no work spoilage caused by dripping oil or grease . . . clean, sustained lubrication is sealed IN. The flexible covers also serve to protect the joints . . . lint and dirt are sealed OUT.

Apex *covered* universal joints will provide long, trouble-free service life on the most difficult drive-line applications, including your own.

PHOTOS COURTESY PARKS-CRAMER COMPANY, FITCHBURG, MASS.



SEE OUR CATALOG IN SWEET'S

or write, on your company letterhead please, for Catalog 28 and Data Sheet.

THE APEX MACHINE & TOOL CO.
1042 South Pattersen Blvd.
DAYTON 2, OHIO

Phantom view of Apex universal joint with lubricant-retaining cover, an exclusive Apex development. Apex covered joints operate efficiently in wet, dry, corrosive or abrasive atmospheres and in extremes of temperatures.

You've never seen a motor like this!

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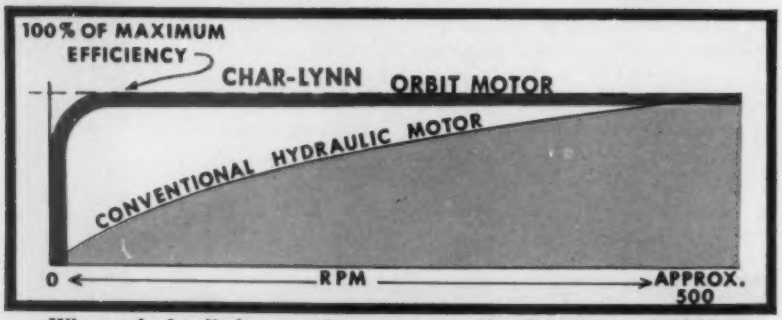
A High Torque, Low Speed Hydraulic Motor

It's Here—A NEW concept in fluid power mechanics has brought about the development of a totally new fluid motor—A *High Torque—Low Speed* motor.

These motors open up complete new areas for design, never before possible. They offer a practical and economical hydraulic solution to the age-old problem of providing High Torque at Low Speeds for constant and variable speed drives—hydrostatic transmissions and remote controls *without* bulky, costly mechanical drives and gear reducers.



Whereas hydraulic losses make some conventional designs prohibitive at the lower speeds, Char-Lynn ORBIT MOTORS maintain high efficiency over the complete operational range.

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HYDRAULIC HORSEPOWER PRODUCTS

form air gap between stator and rotor. Either porous bronze or ball bearings are available. Four-pole units have ratings up to 1/20 hp; two-pole units, ratings up to 1/5 hp. Three-in. dia is constant, while length varies from 3 1/8 to 5 7/8 in. Delivery in 90 days. **Howard Industries Inc, Dept 31, Racine, Wis.**

Circle 328 on Reader Service Card

Hose clamps . . .

are made with solid flat band 1/2 in. wide and in 87 nominal diameters from 3/8 to 6 in. Available in various band shapes for connecting duct or securing insulation. Havé plated fillister head screws and nuts for tightening with screwdriver. Produced of cold-rolled strip steel. **Wittek Mfg Co, 4305 W 24th Pl, Chicago 23.**

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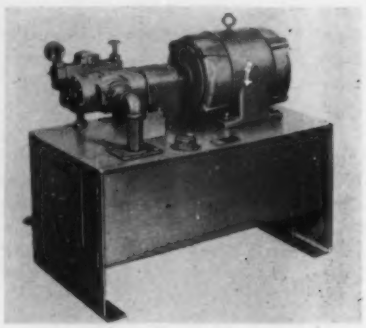

Double-pump power units . . .

operate at 1000 and 2000 psi. Available in 30- and 60-gal. reservoir sizes with combined pump capacities to 33 gpm. Each has 1800-rpm motor. Use with an unloading valve panel is said to reduce hp requirements and lower oil temperatures. Can be supplied with two individual relief valves when two separately-operated hydraulic systems are required. **Hannifin Co, Dept 126, 501 S Wolf Rd, Des Plaines, Ill.**

Circle 330 on Reader Service Card

Clear-silicone potting compound . . .

for electronic assemblies, cures at 158 to 176 F to a flexible, resilient, self-supporting, non-flowing solid. Components imbedded in material be repaired or replaced by removing a section of the material with a sharp instrument. New material, poured into cutout section, cures without leaving repair evidence. Has 800 to 1500 centipoise viscosity in uncured form and flows freely in and around complicated parts. Resists thermal shock of 5 cycles from 149 to 257 F. Potted assemblies cure in 16 hr at 167 F; in 72 hr at room temperature. Useful range is —85 to

continued on page 76

PRACTICAL TOLERANCES CAN CUT GASKET COSTS

Close tolerances in resilient gasket thickness are seldom necessary. Units with extremely close assembly tolerances can usually be sealed with compressible cork-and-rubber materials made to commercial standards.

Tolerances in gasket thickness do not become critical if the material chosen seals effectively over a wide range of compressions.

Armstrong cork-and-rubber compounds are typical of such materials. They will compress from 20% to 33% —depending on the amount of cork in the particular compound—without excessive sideflow.

The cork content of these materials makes them truly compressible. They actually decrease in volume under load. This makes them particularly valuable where the gasket is confined without relief. The absence of sideflow makes it easy to mate flanges.

Tolerances in the gauge of cork-and-rubber gaskets can be as wide as ±.015". This means that commercial tolerances for such materials are perfectly satisfactory for practically all applications.

Equally important—in some cases, more important—the compressibility of cork and rubber sometimes permits increases in the tolerances of the metal components, producing important savings in machining time.

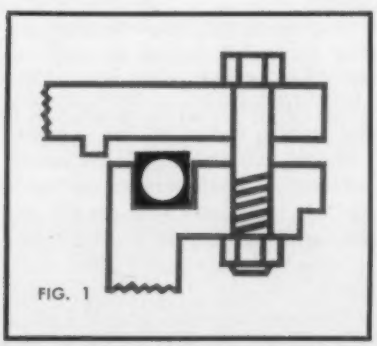

Figure 1. Note the relative sizes of a cork-and-rubber gasket and a comparable non-compressible molded ring. While the ring must be made to very close tolerances, cork-and-rubber's tolerance is not critical.

Figure 1 illustrates the relative sizes of a cork-and-rubber gasket and a comparable non-compressible molded ring. The resilient cork-and-rubber compound permits wide tolerance in its size. The molded ring, however, must be made to very close tolerances to allow perfect fit between the flanges.

Similarly, in figure 2, wide tolerance cork-and-rubber gaskets make an effective packing ring. Their true compressibility controls lateral flow and prevents build-up of radial pressure on the shaft.

When non-compressible rings were used on the flanged journal of the calender roll shown in figure 3, extremely close tolerances were required. Undersized rings leaked. Oversized rings prevented metal-to-metal contact between the flanges and caused misalignment. Both problems were solved with standard-tolerance cork-and-rubber rings, which fitted perfectly and sealed tightly.

There are fifteen different Armstrong cork-and-rubber materials available, including four sponged types. These compounds are made with nitrile-, styrene-, chloroprene-, or butyl-type synthetic rubber binders.

The chemical resistance of these compounds is comparable to that of the corresponding base polymers. Several Armstrong materials meet MIL-G-6183 and other specifications.

In density, Armstrong cork-and-rubbers range from soft, cork-like compounds to very firm compositions that are nearly as incompressible as straight rubber materials. All non-sponged compositions are impervious in their uncompressed state.

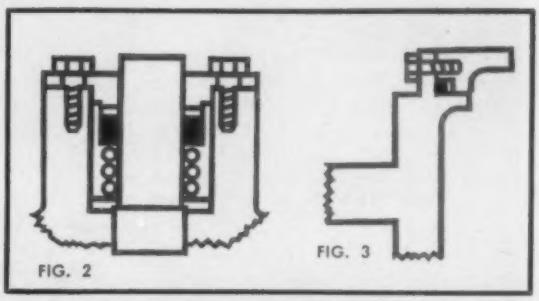

Figure 2. As a packing ring, cork-and-rubber does not build up excessive radial pressure on the shaft.

Figure 3. Cork-and-rubber gasket on flanged journal of calender roll.

We also offer special-purpose compounds based on silicone and fluorocarbon polymers for use at temperatures 100° F. to 150° F. above the limit for presently available standard cork-and-rubbers. These special compounds have compressibility in the range of 15% to 25% at 400 psi.

A catalog describing all Armstrong materials will be sent on request. Detailed information on the selection, design, and performance of resilient gasket materials is contained in the Armstrong Gasket Design Manual. Write for your free copy today. Address Armstrong Cork Company, 7101 Irvin Street, Lancaster, Penna.

Armstrong GASKET MATERIALS

347 F. Priced at $10.50 per lb in 1-lb quantities; $7.50 per lb in gal. quantities; and $7 per lb in drum quantities. **General Electric Co, Silicone Products Dept, Waterford, NY.**

Circle 331 on Reader Service Card

Neon indicator . . .

rated at 0.001 amp at 115 v ac, has built-in 62,000-ohm resistor. Weighs 0.020 lb, is front- or rear-panel mounted, and uses MS25252 NE20 lamp. Lens come in three colors. **Micro Switch Div, Controls Company of America, Folcroft, Penna.**

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Deposited-film potentiometer

provides greater than 0.01% resolution. Thin-film metallic resistance element is produced in a high-vacuum chamber using electron bombardment. Can be resolved into extremely small changes in resistance. Available in single or ganged types with shaft and housing adaptable for servo or panel-mounted uses. **Mechatrol Div, Servomechanisms Inc, 1200 Prospect Ave, Westbury, LI, NY.**

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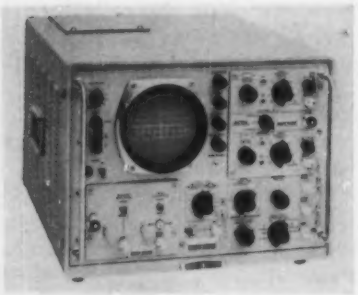


30-mc oscilloscope . . .

provides 24 calibrated sweep times—from 0.1 microsec, cm to 5 sec, cm with ±3% accuracy. Seven-range magnifier increases fastest sweep to 0.02 microsec, cm. Horizontal amplifier sensitivity is 0.1 to 11 v, cm. Nine-range internal calibrator provides voltages from 0.2 milliv to 100 v. Accepts time axis plug-in units, as well as vertical amplifiers. Priced at $2,150. Delivery in 10 wk. **Hewlett-Packard Co, 1501 Page Mill Rd, Palo Alto, Calif.**

Circle 334 on Reader Service Card

DESIGN LITERATURE

The Waste Makers

VANCE PACKARD. David McKay Co Inc, 119 W 40th St, New York 18. 5¾ x 8¼, 340 pp. $4.50.

Whether you design consumer products or the machines and equipment that produce them, your job is going to be seriously affected by the outcome of the debate now going on in the US over our economic system and its future. *The Waste Makers* is a part of that debate. Packard quotes R. J. Saulnier, chairman of President Eisenhower's Council of Economic Advisers, "As I understand the economy, its ultimate purpose is to produce more consumer goods." And from Sen J. S. Clark Jr, Pennsylvania, "The goal of our economy is not the production of more consumer goods at all . . . (it) is to provide an environment in which every American family can have a good house for living and shelter, a good school to which to send the children, good transportation facilities, and good opportunities for cultural and spiritual advancement."

Several PRODUCT ENGINEERING readers have been taking part in this debate, in our "Reader-to-Editor" columns. Their letters revealed that they, too, realize the debate is not academic, of interest only to economists and sociologists. Their letters started coming in long before Packard began recording the effects that ostentatious product decoration, planned obsolescence and the other currently fashionable market gimmicks have had on our fast-disappearing national resources. As a matter of fact, Packard frequently quotes from these letters and the editorial columns of PRODUCT ENGINEERING.

It is imperative that this book—in spite of its many faults— be defended and even circulated by all concerned with their integrity, competence and future as engineers, designers and editors in the product-development field. Vance Packard has long been out of favor with the "waste makers"—those of our specialists in management and marketing, who consider sales volume and attendant profits as ends that can justify any kind of retailing means. They disapprove strongly of his *Hidden Persuaders* and *The Status Seekers*.

The marketers' main defense seems to be that no one can make the consumer buy what he doesn't want. What could be more beside the point in a market where the advertising and promotional apparatus boasts of its ability to change these wants, with the help of more funds and influence than any other propaganda group has had at its command in all history?

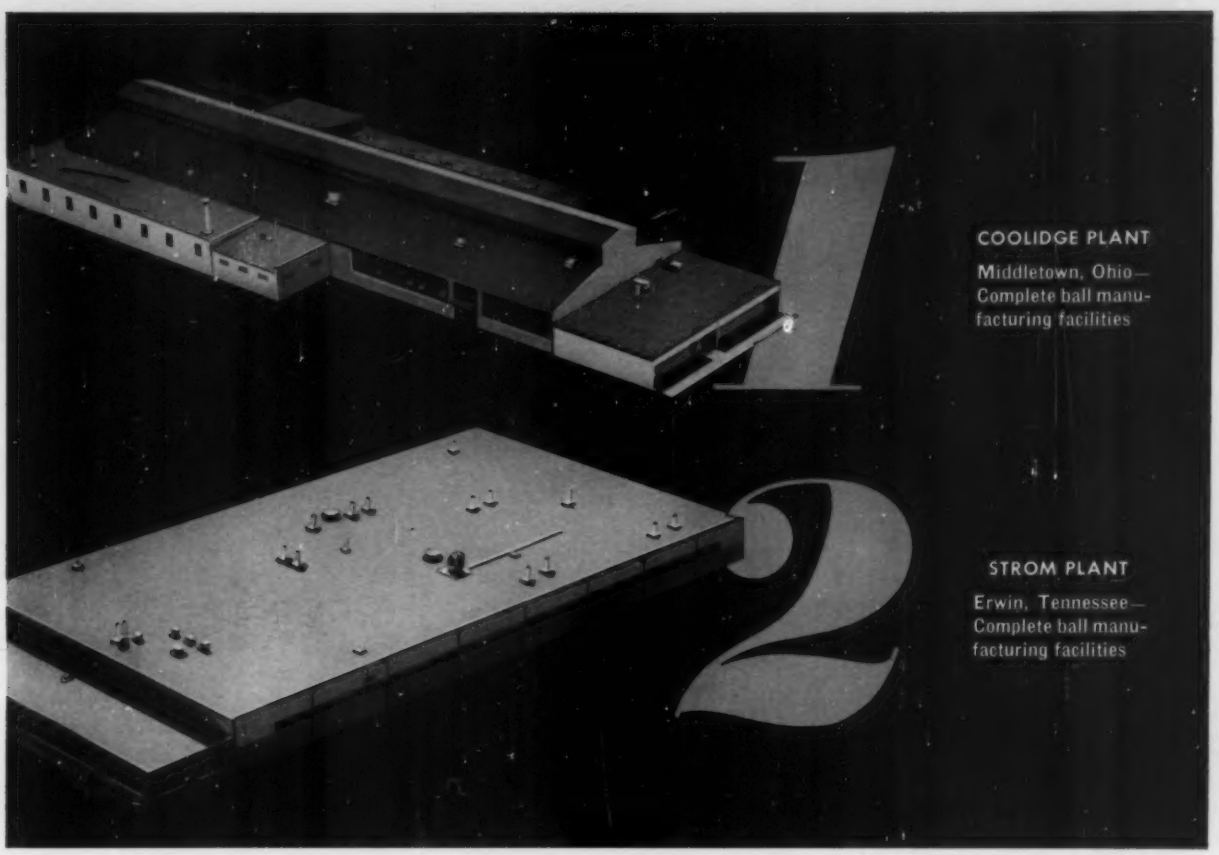
Since early in the 1950s there has been much detailed and varied discussion and analysis of the American economy in all sorts of academic, political and social contexts. But Packard, in this book, shows little awareness of this debate. This is revealed most sharply by the curious shallowness of the references he lists. They represent little more than a collection of business and technical publications, some popular magazines, and a few of the more popular books of recent years on economics and sociology. This reviewer could not avoid the conclusion —despite the author's obvious earnestness—that he never reaches beyond the symptoms to examine the causes of our problems, as the most highly industrialized of the world's societies.

Engineering readers will be annoyed to note that Packard fails to distinguish most of the time between genuine and useful product innovations and new gadgetry. At the same time, they must approve his conclusion that we are not overproducing in general but, instead, are permitting potential profit rates to be the chief —and sometimes only—factor in determining where capital should be invested.

Such readers will probably also agree that Packard is logical in proposing development and production of the goods and services urgently needed in the public sector of the economy (schools, hospitals, roads, urban rehabilitation, health services and facilities, etc.) as a new field for the productive resources now devoted to the overemphasized parts of the private sector.

However, engineering readers whose jobs depend on their ability to plan and make provision for functional and environmental eventualities will wonder why Packard fails to propose the

continued on page 78



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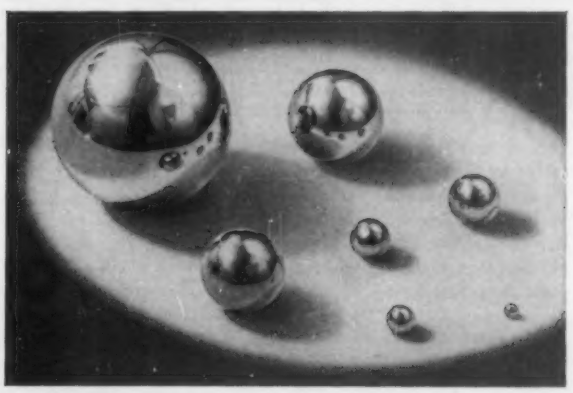
Hoover offers America's widest selection of standard balls in chrome, carbon, stainless steel, brass, bronze, monel and other metals. A wide range of sizes and grades for most industrial applications is available. For complete information, mail the coupon.



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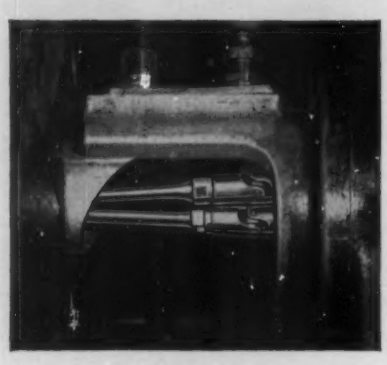
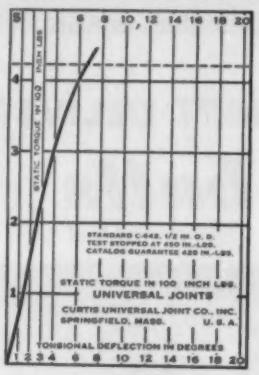
Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.

Torque Curve ½" Curtis Universal Joint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materials-allocation and production-quota system so clearly implied in his conclusion. For those readers fearful of "big government," this reviewer offers his favorite quote from the book, "Any differences between private and public bureaucracies today are relative —and quite possibly less important than their similarities."

In closing, Packard reminds us that more Americans (13.5 million) than ever before are to enter the labor market during the just-beginning sixties, which are certain to see even greater achievements in labor productivity through automation. Packard does not go on to point out that already all of the manufactured products currently being marketed are produced by a work force that totals less than half of all employed Americans. Yet the overproduction that exists in many of these product lines should not be particularly startling, because in American agriculture a much tinier minority of our people has long been producing more food than we can buy and the government can hoard.

Just how we are to solve this seeming embarrassment of riches is one of the impending crises of the sixties. Another with which it is inseparably linked is the inevitability of war or disarmament—with its attendant dismantling of the armaments industry (a problem Packard only mentions in passing). These are among the questions raised by *The Waste Makers*. They are quite unavoidable for PRODUCT ENGINEERING's readers and editors alike. —JK

Linear Programing and the Theory of the Firm

Edited by K Boulding and W Spivey. Macmillan Co, 60 Fifth Ave, NY 11. 6¼ x 9½, 227 pp. $8.

Here are seven papers written by economists, for economists. But there's something here for the design engineer too. The tools of the new mathematics are described and explained and can serve the engineer as well as the economist. Chapter I provides a quick look at linear programing, game theory, organization theory. Chapter 2 introduces the theory of sets and some mathematical fundamentals including matrix algebra. Linear programing as a management tool is described in Chapter 3, but the mathematical methods are not handled in any detail (the simplex method, for example, is described in an appendix to the chapter). The ad aims of operations research and its application to economic problems are discussed in Chapter 5. A little offbeat for the engineer, perhaps, but worth looking at for its different viewpoint on a new subject. —CJL

ABSTRACTS FROM THE LITERATURE

Ball Bearings in Liquid Nitrogen

On the basis of the work described, it is concluded that ball bearings incorporating filled polytetrafluoroethylene ball separators are superior to bearings incorporating the other separator materials tested when operating submerged in liquid nitrogen. This filled PTFE material exhibits a relatively low coefficient of friction together with a high resistance to wear at liquid-nitrogen temperature, which are the properties that contribute to its high durability in this application.

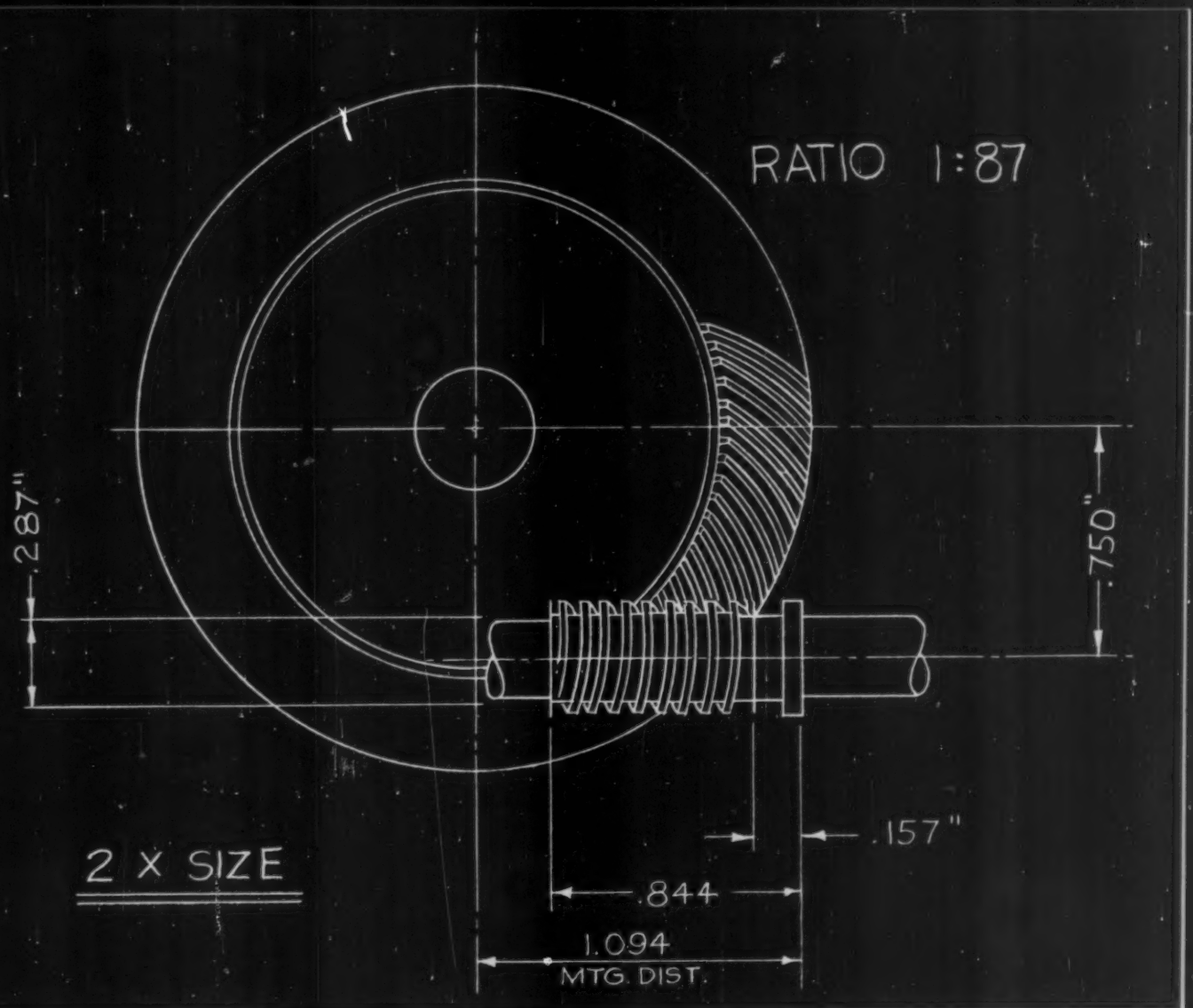
"Evaluation of Ball Bearing Separator Materials Operating Submerged in Liquid Nitrogen," Wilson, Brennan, Birmingham, Cryogenic Engineering Laboratory; Martin, Argonne National Laboratories. American Society of Lubrication Engineers Paper No. 60 LC-4, 5 N Wabash Ave, Chicago 2.

Incremental Servos

Part I of this series points out that all stepping motors can be broadly classed as either solenoid-ratchet or phase-pulsed synchronous devices. In Part II the operation of each of these two classes is discussed, using a single example in each case. The author then goes on to take a quick look at the importance of inertial load matching and concludes with an interesting review of the analytical nature of stepping controls—how they resemble.

continued on page 80

"The way Crenshaw is carrying on over that drawing, his watch'll be wound tight through '62 . . ."



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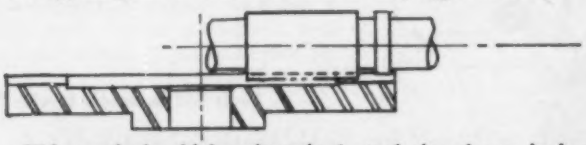
This is the finished prototype of a new high-ratio hypoid gear. Our customer will now produce it, royalty free, on his Gleason equipment.

This is but one example of what Gleason engineering service can do for people who need gears. Our facilities and advice are at your constant disposal for development of bevel and hypoid gears to meet the needs of any application.



This particular high-ratio pair (actual size shown in insert) offers several advantages over conventional gears:

GREATER STRENGTH. High-ratio hypoid pinions are larger and stronger than corresponding bevel pinions.

COMPACTNESS. Where space is a problem, the high-offset principle lets you design a more compact and flexible unit than the corresponding worm and wheel.

SMOOTHER ACTION. High-offset pairs provide smooth, quiet tooth action . . . *continuous* action even with only one or two teeth, because of the way the teeth wrap around the pinion.

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MULTI-ZONE HEAT CONTROL permits exact settings of temperature profiles — for quality work on each brazing, alloying, metal bonding or soldering cycle. When working with parts of unequal section, a pre-heat zone insures stabilized heat throughout the mass.

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WORK HANDLING IS EASIER, too, with a Hayes Model LAC-200 Series Furnace. Loading tables combine with constant belt feed to make this a remarkably high-production unit, per dollar cost and per foot of floor space.

VERSATILITY COUNTS. While designed for brazing, your Hayes furnace can double for annealing, hardening, and other heat treat operations. It's a bull for work!

WHATEVER YOUR BRAZING NEED — from silver (1100°F range) to platinum (3400°F range with type M-Y or Vacuum Furnaces), Hayes know-how in equipment and engineering can come up with a RESULTS GUARANTEED answer . . . tested in our lab. on full-production equipment . . . proven by scores of successful installations in industry. Bulletin 5711A gives LAC details. For your copy, write C. I. Hayes, Inc., 958 Wellington Ave., Cranston 10, Rhode Island.

C. I. HAYES, INC.

Established 1905

It pays to see Hayes for metallurgical guidance, lab. facilities, furnaces, atmosphere generators, gas and liquid dryers, Pow-R-Trol (TM) control units.

and differ from, the more conventional servo types. Part III covers the application of the stepping motor to a wide variety of incremental servo systems. Block and circuit diagrams illustrate such widely divergent applications as a digital differential altimeter, a rail car sorting system, and a simple asynchronism detector.

"Incremental Servos", S. J. Bailey, Vitro Corp of America. Control Engineering, Nov, Dec '60, Jan '61; 330 W 42nd St, New York 36

Relaxation Phenomena in Lubrication

Lubricants, like other materials, possess both elastic and viscous properties. The degree to which these properties manifest themselves depends on the molecular complexity of the lubricant, the stress range over which it is tested and the time scale on which the observations are made. Simple hydrocarbons of low viscosity exhibit elastic properties only in time intervals of about 10^{-12} to 10^{-9} seconds. The introduction of high-molecular-weight polymers would lengthen this time interval to 10^{-6} to 10^{-4} seconds. Semi-solid lubricants, such as greases, appear to behave elastically, even in time intervals of 0.1 sec or longer.

The significance of these elastic properties can be readily appreciated if one compares the above-mentioned time intervals with loading times in actual dynamically loaded machine elements. Calculations indicate that these loading times range from about 10^{-3} to 10^{-6} seconds when going from piston rings to ball bearings in turbojet engines. If the time during which the lubricant is subjected to rapid stressing is of the same order of magnitude as the relaxation time, the time in which the elastic properties become apparent, then the lubricant will behave elastically rather than viscously. Under these conditions, the lubricant will be present as an elastic film that can carry heavier loads than a viscous film, and at the same time can prevent contact between the bearing surfaces and thus reduce or eliminate wear.

"Relaxation Phenomena in Lubrication," E O Forster, Esso Research and Engineering Co. Presented at 15th ASLE Annual Meeting, Cincinnati April '60. American Society of Lubrication Engineers, 404 N Wesley Ave, Mount Morris, Ill.

"This isn't the Titantic job . . . it's Mickey Mouse!"

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 85.

ROLLING DIAPHRAGMS—Manual BF-400-A, 28 pp. Contains installation suggestions, application sketches and design formulas for preconvoluted and hand-convoluted types in materials ranging from nitrile silicone to butyl elastomer. Covers shaft torque, piston eccentricity, pressure reversal, hysteresis and other factors. Selection nomograph and dimensional data are included. Bellofram Corp, 50 Blanchard Rd, Burlington, Mass.

Circle 350 on Reader Service Card

FILTERS, REGULATORS, LUBRICATORS—Bulletin 0400-B1, 20 pp. Provides specification and performance data, accompanied by cutaway drawings, on single and combination units. Dimensions and flow rates are tabulated. Hannifin Co, Dept 126, 501 S Wolf Rd, Des Plaines, Ill.

Circle 351 on Reader Service Card

POPPET-TYPE VALVES—Bulletin 323, 8 pp. Outlines specifications, flow factors (C_v) and response times of 25 straightway, 3- and 4-way models. Cutaway drawings show construction features. Ross Operating Valve Co, 120 E Golden Gate Ave, Detroit 3.

Circle 352 on Reader Service Card

ALUMINUM ALLOYS—Brochure, 8 pp. Tabulates chemical composition and physical, mechanical and elevated temperature properties of four alloys in sand, plaster and permanent mold applications. Discusses castability and machinability and provides stability and aging curves, the latter showing rates of change in tensile

continued on page 82

Smallest of the Small. A pigmy beetle could easily crawl through the eye of an ordinary sewing needle, as shown by this equally magnified view of both. Among the tiniest of insects, some species of pigmy beetles reach about one-hundredth of an inch in length.

Miniature for Missiles. This tape recorder, shown one-sixth actual size, is a vital unit in the communications system of the Army's "talking satellite." Constant low-torque and quiet operation of MPB bearings in it maintain accurate tape position.

Man with Miracles. Like all MPB Sales Engineers, Pete Weinert helps solve miniaturization problems — by acquainting people with MPB service and facilities for engineering, research and experimental work. He's ready to do the same for you.

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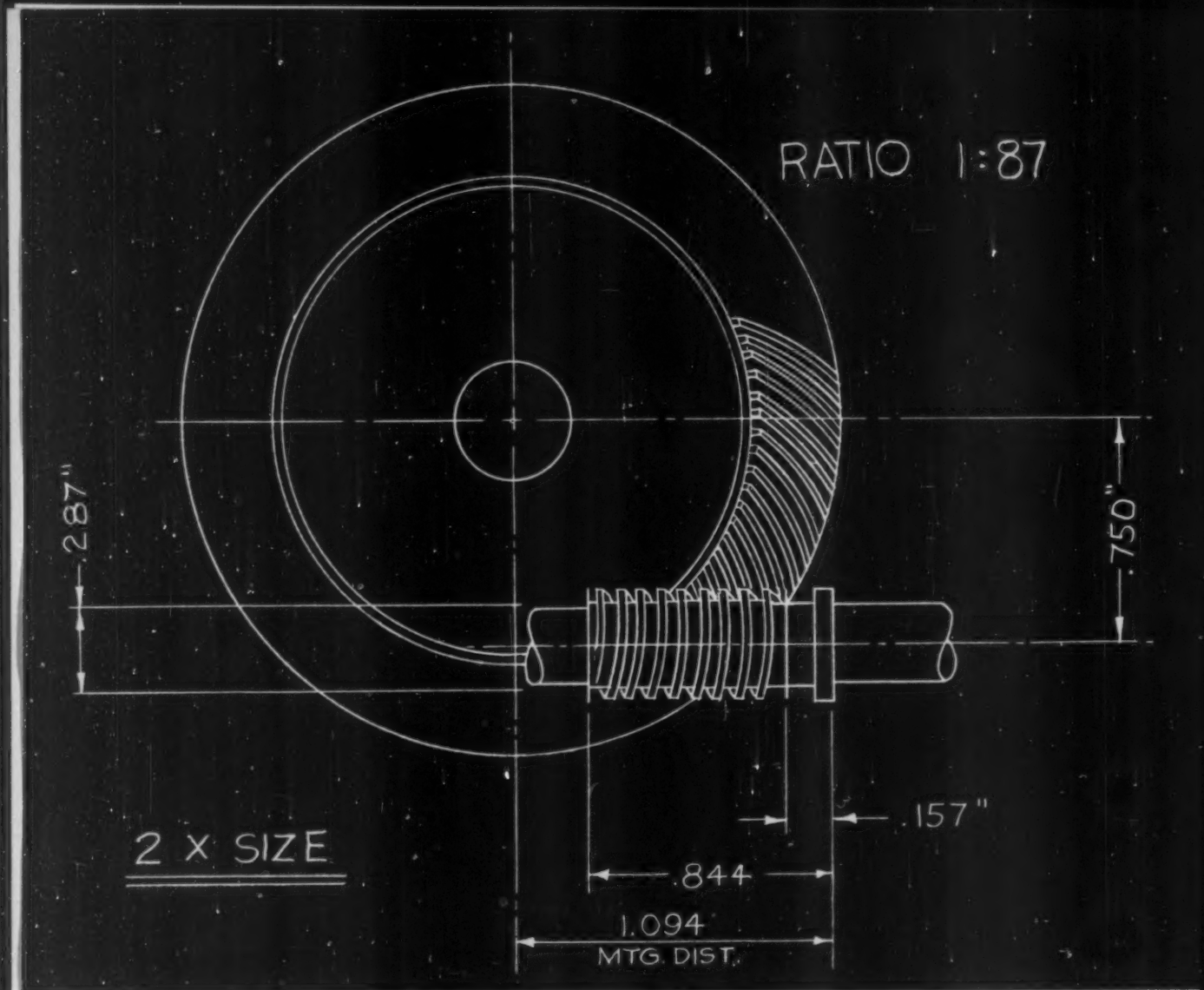
ACTUAL SIZE OF THE MPB BEARINGS IN TAPE RECORDER SHOWN ABOVE

Little Things That Count. There's nothing new, in the larger sense, about ball bearings. But miniaturization of these familiar components is a wholly modern development. Forty years ago, for example, MPB was first to manufacture bearings with O.D.'s as small as ⅜", and with precision that brought new aid to science and industry. Today, after continual pioneering in miniaturization, MPB produces over 500 types and sizes of bearings, ranging down to 1/10" O.D., with specials as required. Our catalog brings you details on these bearings. Write for it, or for engineering advice, to **Miniature Precision Bearings, Inc.**, 91 Precision Park, Keene, N.H.

MPB *Helps you perform miracles in instrumentation*

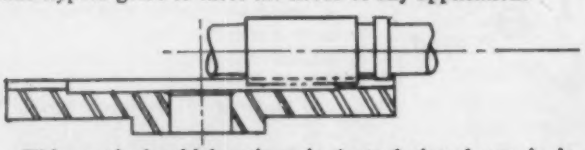
CIRCLE 81 ON READER SERVICE CARD 81



HERE'S ANOTHER GEAR GLEASON BUILT FROM FIRST DESIGN TO FINAL PRODUCT

This is the finished prototype of a new high-ratio hypoid gear. Our customer will now produce it, royalty free, on his Gleason equipment.

This is but one example of what Gleason engineering service can do for people who need gears. Our facilities and advice are at your constant disposal for development of bevel and hypoid gears to meet the needs of any application.



This particular high-ratio pair (actual size shown in insert) offers several advantages over conventional gears:

GREATER STRENGTH. High-ratio hypoid pinions are larger and stronger than corresponding bevel pinions.

COMPACTNESS. Where space is a problem, the high-offset principle lets you design a more compact and flexible unit than the corresponding worm and wheel.

SMOOTHER ACTION. High-offset pairs provide smooth, quiet tooth action . . . *continuous* action even with only one or two teeth, because of the way the teeth wrap around the pinion.

STRADDLE MOUNTINGS. Cylindrical high-ratio pinions, with extended shank, make practical very rigid straddle mountings.

GRINDING. High reduction hypoids are cut on same Gleason equipment used on familiar bevel and hypoid gears. Same testers, quenchers and other auxiliary equipment can be used. Grinders are available for the ultimate in precision and finish to minimize friction.

LET GLEASON MAKE RECOMMENDATIONS. Send along a set of prints, and we'll be glad to study them and give you our thoughts on how best to make the gears you need.

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Smallest of the Small. A pigmy beetle could easily crawl through the eye of an ordinary sewing needle, as shown by this equally magnified view of both. Among the tiniest of insects, some species of pigmy beetles reach about one-hundredth of an inch in length.

Miniature for Missiles. This tape recorder, shown one-sixth actual size, is a vital unit in the communications system of the Army's "talking satellite." Constant low-torque and quiet operation of MPB bearings in it maintain accurate tape position.

Man with Miracles. Like all MPB Sales Engineers, Pete Weinert helps solve miniaturization problems — by acquainting people with MPB service and facilities for engineering, research and experimental work. He's ready to do the same for you.

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MPB *Helps you perform miracles in instrumentation*

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IRIDITE—a specialized line of chromate conversion coatings for nonferrous metals. Easily applied at room temperatures with short immersion times, manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel. Special equipment, exhaust systems or highly trained personnel not required.

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IRIDITE® Chromates | IRILAC® Coatings | ISOBRITE® Brighteners | ARP® Supplies | WAGNER Equipment

and yield strengths and hardnesses. Apex Smelting Co, 2537 W Taylor St, Chicago 12.

Circle 353 on Reader Service Card

FLEXIBLE HOSES–Bulletin 605, 12 pp. Discusses and illustrates proper selection and installation of six hose and two duct types. Prices per foot are tabulated. Flexaust Co, 100 Park Ave, New York 17.

Circle 354 on Reader Service Card

WINGNUTS–Bulletin No. 2004, 4 pp. Lists several hundred blank and special thread or blank and untapped hole dia combinations. Drawings show basic die-cast zinc alloy nuts with available bosses. Gries Reproducer Corp, 400 Beechwood Ave, New Rochelle, NY.

Circle 355 on Reader Service Card

INTEGRAL SQUIRRELCAGE INDUCTION MOTORS–Bulletin 600, 12 pp. Presents performance characteristics, mechanical design variations, construction and insulation information, ratings and dimensions of basic dripproof units ranging from 1 to 150 hp. Century Electric Co, 18th & Pine Sts, St Louis 3.

Circle 356 on Reader Service Card

AIR COMPRESSORS–Bulletin 203, 6 pp. Longitudinal and transverse cross sections show construction features in four models rated at 25, 50, 75 and 100 hp. Specifications from piston displacement to dimensions and weights are listed. Clark Bros Co, Div Dresser Industries Inc, Olean, NY.

Circle 357 on Reader Service Card

TUNNEL DIODES–Bulletin 2106, 4 pp. Discusses electrical characteristics and applications in amplifiers, oscillators and high-speed switches. Describes ways to obtain parameters and shows basic circuit designs. Sperry Semiconductor Div, Sperry Rand Corp, Norwalk, Conn.

Circle 358 on Reader Service Card

SQUIRRELCAGE INDUCTION MOTORS–Bulletin 1150, 6 pp. Describes electrical and mechanical features of guarded dripproof motors in NEMA standard dimension frames 182 through 445U. Tabulates motor speeds, starting and max torques and starting currents in nine different applications. Fairbanks, Morse & Co, Electrical Div, Freeport, Ill.

Circle 359 on Reader Service Card

POLYETHYLENE RESINS–Data sheet, 4 pp. Lists 31 resins according to density, melt index and possible uses. US Industrial Chemicals Co, Div National Distillers & Chemical Corp, 99 Park Ave, New York 16.

Circle 360 on Reader Service Card

continued on page 85

WEATHER

Fair, Mild

T-J

TOMKINS-JOHNSON TRIBUNE

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THE TOMKINS-JOHNSON CO. • 2425 W. Michigan Ave. • Jackson, Michigan

INCREASED PRODUCTION... CREATES PRICE ADJUSTMENT

on T-J Squair Head Cylinders

JACKSON, MICH. JAN. 3 (TP)—"Due to the tremendous initial response and the continuing acceptance and purchase of the new Tomkins-Johnson Squair Head Cylinders, it has been possible to *lower* the basic price," according to T-J personnel. In effecting this price cut, Tomkins-Johnson has again proven that acceptance of a quality product and the inevitable increase in manufacturing volume *CAN* economically justify a price reduction *WITHOUT* jeopardizing quality.

The T-J Squair Head Cylinder, an interchangeable air cylinder for any pneumatic power application, was first introduced by Tomkins-Johnson in 1958. It was an immediate success because of its availability in a wide range of bore sizes and strokes . . . as well as the standard quality features, including the new T-J Super-Cushion for air cylinders.

Other Standard Features

Other standard T-J features that allow the T-J Squair Head Cylinder to retain its high quality comparison over other makes of air cylinders and still give you lower price are; solid steel heads and mounting plates, hard-chrome plated bodies and piston rods, leak-proof cylinder head to body construction, heavy duty, high tensile ground and polished chrome, plated piston rod, and many more . . . STANDARD AT NO EXTRA COST.

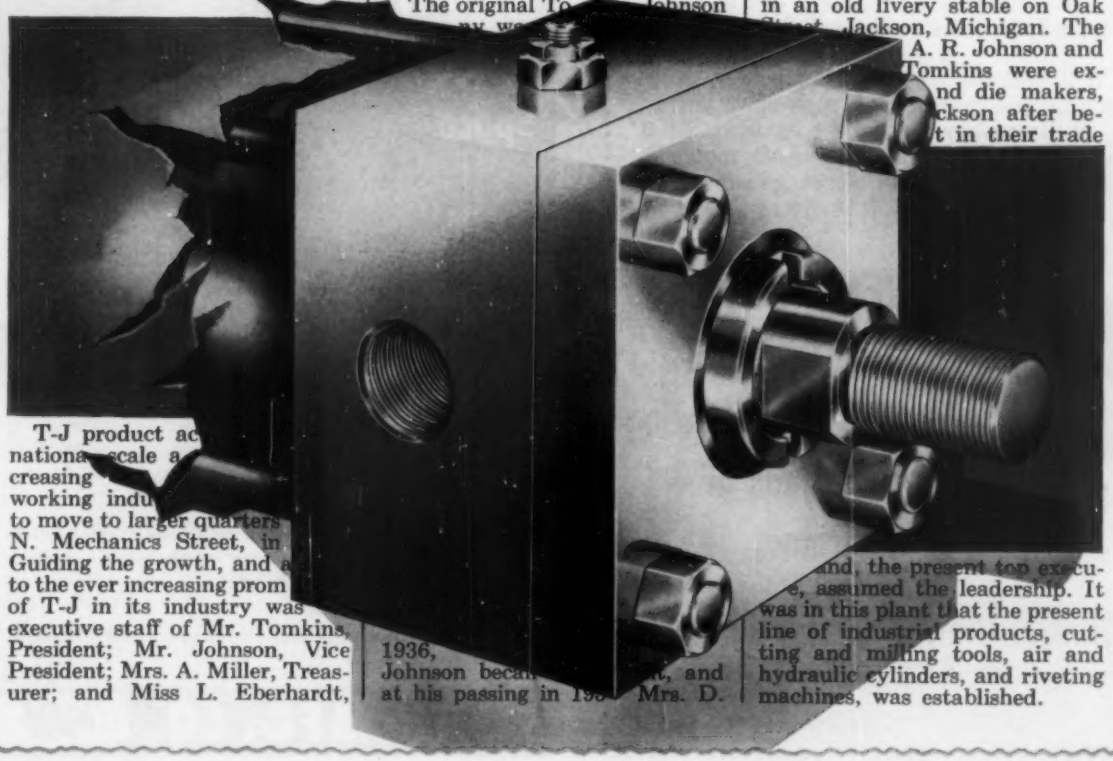
Tomkins-Johnson, by virtue of the announced lower cost on its Squair Head Cylinder, wish to thank their customers for their initial acceptance which has been such a contributing factor in this price reduction.

T-J Produces Complete Line

Tomkins-Johnson also produces a complete line of hydraulic and pneumatic cylinders for *EVERY* power drive application . . . including the very popular Spacemaker. If you need further information or complete catalog material, write T-J direct, or request it from your T-J sales representative.

The Tomkins-Johnson Company was founded in 1917

The original To Johnson in an old livery stable on Oak Jackson, Michigan. The A. R. Johnson and Tomkins were ex- nd die makers, ckson after be- t in their trade



T-J product ac nationa scale a creasing working indu to move to larger quarters N. Mechanics Street, in Guiding the growth, and a to the ever increasing prom of T-J in its industry was executive staff of Mr. Tomkins, President; Mr. Johnson, Vice President; Mrs. A. Miller, Treasurer; and Miss L. Eberhardt,

1936, Johnson becam t, and at his passing in 19 Mrs. D.

nd, the present top execu- e, assumed the leadership. It was in this plant that the present line of industrial products, cutting and milling tools, air and hydraulic cylinders, and riveting machines, was established.

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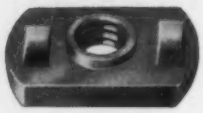
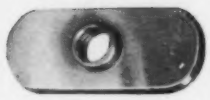
OHIO WELD NUTS



Patent 2908310

RN NUT—for projection welding. Ideal where tension is against the weld.



ND NUT—for spotwelding. Used where large nut is needed for bridging two sheets or for extra strength.

PN NUT—for projection welding. Ideal in confined areas, on heavier gages, or on curved surfaces.

Patent Applied For

XN NUT—for spotwelding with recessed target electrode area. Full range of sizes can be welded with 20 KVA Welder.

Thread Sizes #6-32 to 3/8-16

Samples and information furnished upon request.

The OHIO WELD FASTENERS Primary Fastener in Fastener Assemblies

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This Compact FUNK Unit *SAVED* Space

On this Jaeger concrete mixer, a FUNK-designed double right angle drive provides perfect alignment and positive chain adjustment. Mounted vertically on the "unitized" front trunnion stand, FUNK's unit takes up only a fraction of the space normally used in such applications.

Just one example of how FUNK MODULAR POWER UNITS may be combined in an unlimited number of arrangements — *without* special engineering costs.

Let FUNK solve your power transmission problem.

FUNK MFG. CO. Box 577-D Coffeyville, Kansas

CIRCLE 84 ON READER SERVICE CARD

CIRCLE 207 ON READER SERVICE CARD

THIN-SECTION BEARINGS—Bulletin S-109, 4 pp. Describes ball radial bearings from stock in 90 sizes with 4 to 12-in. bores and custom bearings with 4 to 40-in. bores. Tabulates dimensions of seven standard ball bearing series and one series of taper roller bearings. Kaydon Engineering Corp, Muskegon, Mich.

Circle 361 on Reader Service Card

NYLON THREADED FASTENERS—Specification sheet, 1 pp. Covers round, binding, oval, washer, flat and fillister head types available for nylon machine screws and plain, oval, cone, flat, half- and full-dog point types for headless set screws. Gries Reproducer Corp, 400 Beechwood Ave, New Rochelle, NY.

Circle 362 on Reader Service Card

CENTRIFUGAL MOTOR-PUMPS—Folder 70287, 4 pp. Gives rated head figures for models ranging in output from 15 to 500 gpm. Also traces approximate dimensions of seven pumps with ¾- to 7½-hp motors. Ingersoll-Rand Co, 11 Broadway, New York 4.

Circle 363 on Reader Service Card

PRECISION OPTICS—Brochure, 4 pp. Discusses and illustrates manufacture of optical elements and explains design and engineering services offered. Plummer and Kershaw, East Greenville, Penna.

Circle 364 on Reader Service Card

FLAT-BELT PULLEYS—Bulletin 22103, 4 pp. Tabulates dimensions and prices (according to face widths) of 21 straight and crown-face type pulleys and four tapered bushings. T B Wood's Sons Co, Chambersburg, Penna.

Circle 365 on Reader Service Card

EXPLOSIVE VALVES—Bulletin 116-OXV, 4 pp. Lists specifications and contains schematics showing valve operation. Dimensions are tabulated. Conax Corp, 2300 Walden Ave, Buffalo 25.

Circle 366 on Reader Service Card

TRANSISTOR-EQUIPPED NULL INDICATORS—Catalog sheet, 2 pp. Contains specifications, block diagram and circuitry description of battery-operated and internal ac-powered models. Gertsch Products Inc, 3211 S La Cienega Blvd, Los Angeles 16.

Circle 367 on Reader Service Card

ELECTRONIC ADJUSTABLE-SPEED DRIVES—Bulletin GEA-7208, 4 pp. Contains construction, application and dimensional data on half-wave, fractional-hp drives using silicon controlled rectifiers instead of tubes to supply power to motor. General Electric Co, Schenectady 5.

Circle 368 on Reader Service Card

ZERO GOVERNORS—Bulletin 114, 4 pp. Covers weights, dimensions, capacities and spring recommendations for ⅜- to 6-in. sizes. Includes cutaway drawings of five models. American Meter Co, 920 Payne Ave, Erie 6, Penna.

Circle 369 on Reader Service Card

TRANSFER VOLTAMMETERS—Folder EL 6077, 6 pp. Provides voltage and current ranges of three series with frequencies from 5 to 50,000 cps at a 0.05% accuracy. Engelhard Industries Inc, 75 Austin St, Newark 2, NJ.

Circle 370 on Reader Service Card

VENDOR COORDINATION—Bulletin, 4 pp. Describes service which keeps tabs on vendor production schedules to keep supplies moving at expected rate. Matco Systems Inc, 46 Grace Ave, Great Neck, NY.

Circle 371 on Reader Service Card

LETTERHEAD REQUESTS ONLY

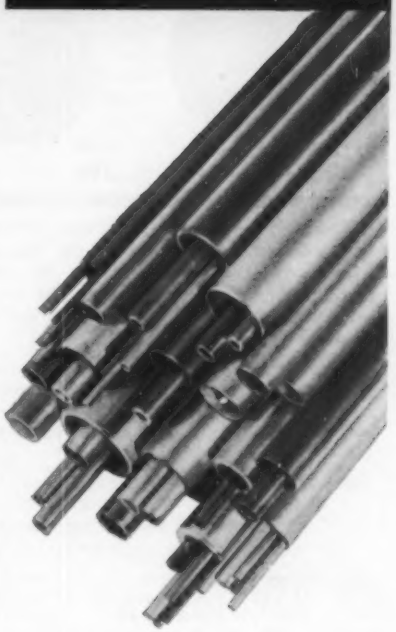
Manufacturers who published following literature asked that requests for copies be made on company letterheads.

CAST HARDENABLE STAINLESS STEELS—Technical report, 24 pp. Discusses heat-treating variables of three alloy types that have chemistries suitable for investment casting. Contains results of recent studies on transformation behavior and chemical effects of these alloys. Also presents test bar results. WaiMet Alloys Co, Div Howe Sound Co, 5320 Oakman Blvd, Dearborn, Mich.

HOSE AND FITTINGS—Catalogs A, B, C-1M-60, 60 pp. Cover hose, tubing and fittings, and 37° flare fittings, in three illustrated sections, each containing specifications and application data. Formrite Tube Co, Two Rivers, Wis.

"Don't worry about getting this all done today, Frimley. Take it home with you."

WANT TUBING IN A HURRY?



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UNIFORM TUBES stocks thousands of pieces of seamless tubing in a wide variety of materials—alloys of aluminum, copper, nickel, steel, glass-to-metal sealing, etc.—in sizes from .625″ to .005″ O. D. and wall thicknesses down to .001″. These pieces are overruns on regular close-tolerance production orders, economically made and stocked for your convenience on preliminary design or parts fabrication set-up work.

Write or phone your needs. We will help you if we can—anticipating your volume requirements later on.

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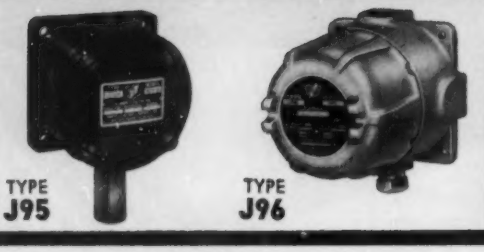
HUxley 9-7276 TWX-CGVL 1044

HAZARDOUS CONDITIONS? **J95 / J96**

Use UE Explosion Proof PRESSURE-VACUUM CONTROLS



The Types J95 and J96 Pressure-Vacuum Controls are designed for applications in hazardous locations where explosive vapors or gases are present and close on-off differential control is required. In both units, pressure settings are uncalibrated and adjustment is made by an internal nut.

Adjustable Range . . .	J95 — Various ranges between 0 and 500 psi limits. J96 — Various ranges between 0 and 180 psi limits.
Switch Differential . . .	J95 — Factory pre-set for any differential between 2 and 30 psi. J96 — Factory pre-set for any differential between 3" W.C. and 2 psi.
Switch Ratings	Up to 15 amps. at 115 or 230 volts A.C. 20 amp. A.C. or D.C. switches also available.
Switch Types	N.O., N.C., or Double Throw — no neutral position.
Maximum Pressure . .	J95 — Up to 600 psi. J96 — Up to 180 psi.
Electrical Connections .	J95 — Lead wires attached to screw type terminals on switch via ½" NPT opening. J96 — Lead wires attached to terminal block via ¾" NPT opening.
Pressure Connection . .	Via a ¼" female NPT connection.
Enclosure	J95 — Cast iron with a gray, baked-enamel finish. For use in Class I, Groups C and D locations. J96 — Cast iron base and aluminum cover. For use in Class I, Group D; Class II, Groups E, F, and G; or Class III locations.
Mounting	Surface-mounted by four corner holes with clearance for ¼" screws.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. For information on modifying standard units or providing custom-built units, consult a UE application engineer. For additional data on the Types J95 and J96, request new literature available.*

UE®
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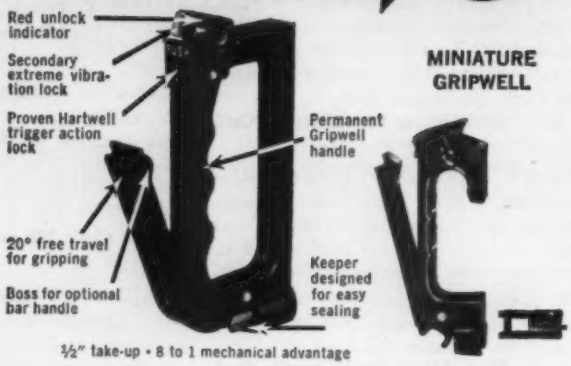
COMPANY
91 SCHOOL STREET, WATERTOWN, MASS.

WHEN QUALITY IS YOUR TARGET...

THE GRIPWELL ELECTRONIC CHASSIS LATCH HELPS YOU HIT THE BULLSEYE


Red unlock indicator
Secondary extreme vibration lock
Proven Hartwell trigger action lock
20° free travel for gripping
Boss for optional bar handle
Permanent Gripwell handle
Keeper designed for easy sealing
MINIATURE GRIPWELL
½" take-up • 8 to 1 mechanical advantage

GRIPWELL® ELECTRONIC CHASSIS LATCH

A handsome, strong and durable handle latch to fasten "plug-in" type electronic chassis, providing for positive ejection and injection of the chassis and allowing an eight to one mechanical advantage, with a total one-half inch take up.

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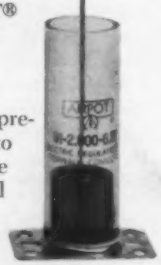
CIRCLE 208 ON READER SERVICE CARD

When the UNPREDICTABLE *happens*

• • • the kind that creeps into the performance of newly completed systems. (Excess vibration here — slight time delay or damping needed there. Or perhaps stability doesn't match the data projected on paper.) To counter these variations, many of our customers have found the AIRPOT® an inexpensive problem solver.



AIRPOT is an air-damping dashpot; precisely constructed to operate within close tolerances. Its small size will rarely disturb a system's basic design.

To learn more about the AIRPOT, contact us at:

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"leaders in automatic control and regulation"

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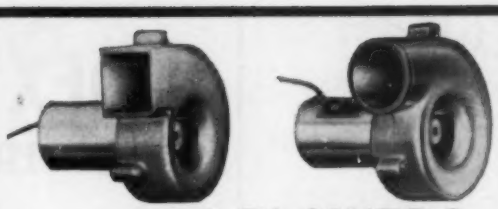

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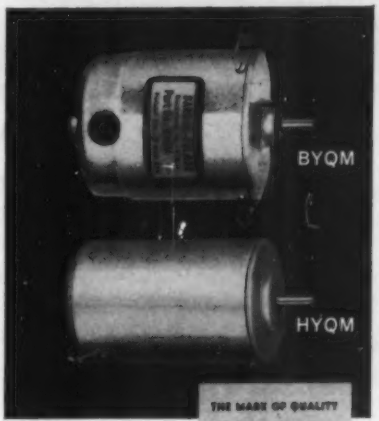

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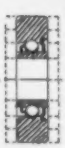

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1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
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*MULTIPLE PRODUCT ADS

Key No.	Specific Product

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Name ..... Title .....

Street .....

City ..... Zone ..... State .....

Company ..... Major Product Manufactured .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
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6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
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9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
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16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
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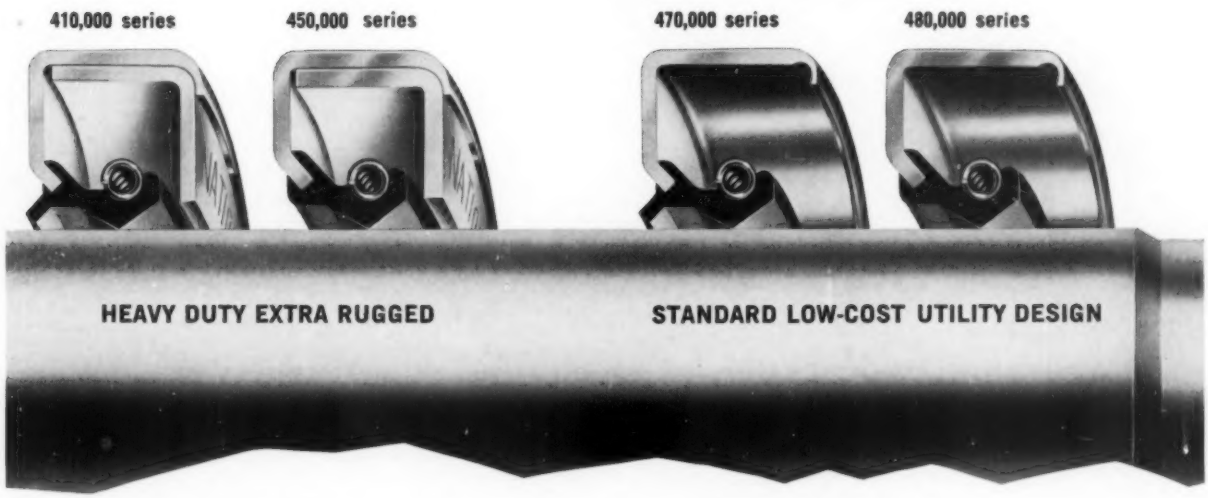

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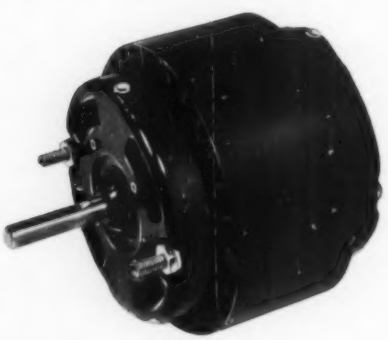

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